

IEC 61850 OVERVIEW

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CONTENT

- Design objectives and scope IEC 61850
- Content and structure of IEC 61850
- Features of IEC 61850
- Application modeling
- Information exchange and communication services
- The 14 parts of the standard
- Future Directions

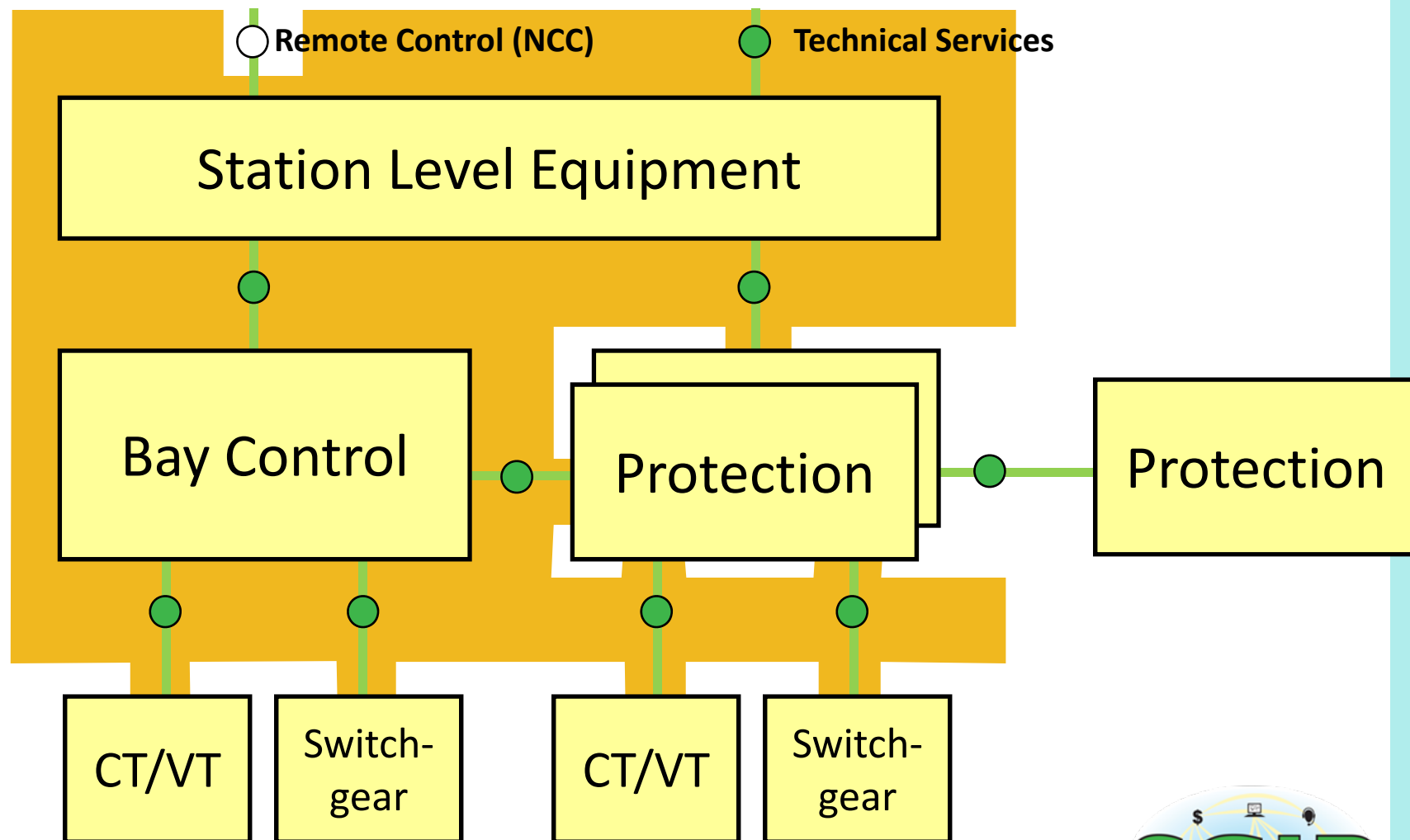


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IEC 61850 – ORIGINAL SCOPE



GOALS OF THE IEC 61850 STANDARD

•Interoperability

- Exchange information between IED's (Intelligent Electronic Device) from several manufacturers
- Use this information for the own function

•Standardized Configuration

- Allocation of functions to devices
- Support any philosophy of our customer – centralized or decentralized systems



GOALS OF THE IEC 61850 STANDARD

- Long Term Stability

- Future proof
- Follow progress in mainstream communication technology
- Follow evolving system requirements needed by our customers



TRADITIONAL UTILITY SCADA

- SCADA protocols have traditionally been designed to optimize:
 - Bandwidth - # of bytes on the wire
 - Hardware utilization - processor speeds, RAM and ROM space
- DNP, ModBus, IEC 60870-5 emerged from a broad family of protocols to provide a first level of interoperability



TRENDS IN APPLICATION REQUIREMENTS

- Deregulation adds to the complexity due to increased data sharing
- Greater intelligence implies more points to be monitored
- Increased number of points implies higher costs for maintaining databases
 - commissioning costs in verifying points
 - more applications accessing the data
 - increased complexity of the applications



TRENDS IN TECHNOLOGY

- Drastic reduction in bandwidth constraints
 - Serial technologies (1200 → 56KB)
 - LAN technologies (1MB → 1GB)
 - Frame Relay, ATM, Fiber, etc.
- Drastic reduction in costs due to
 - standards such as Ethernet and TCP/IP
 - explosion of communications markets
- Advances in hardware capabilities



TRENDS IN TECHNOLOGY

- Object oriented communications organize data by function
- Standardized object models simplify application integration
- Self-description and meta-data allows for on-line validation
- Bandwidth changed from constraint into a resource to solve more expensive problems.



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IEC 61850 STANDARD SERIES

- Title: Communication networks and systems in substations
- The functionality goes far beyond traditional solutions like DNP3, LON, IEC 60870-5-x, ...:
 - dynamic report-by-exception to multiple clients
 - domain-specific and extensible object models
 - standardized XML-based configuration language
 - self description of devices (contain information model) for on-line validation

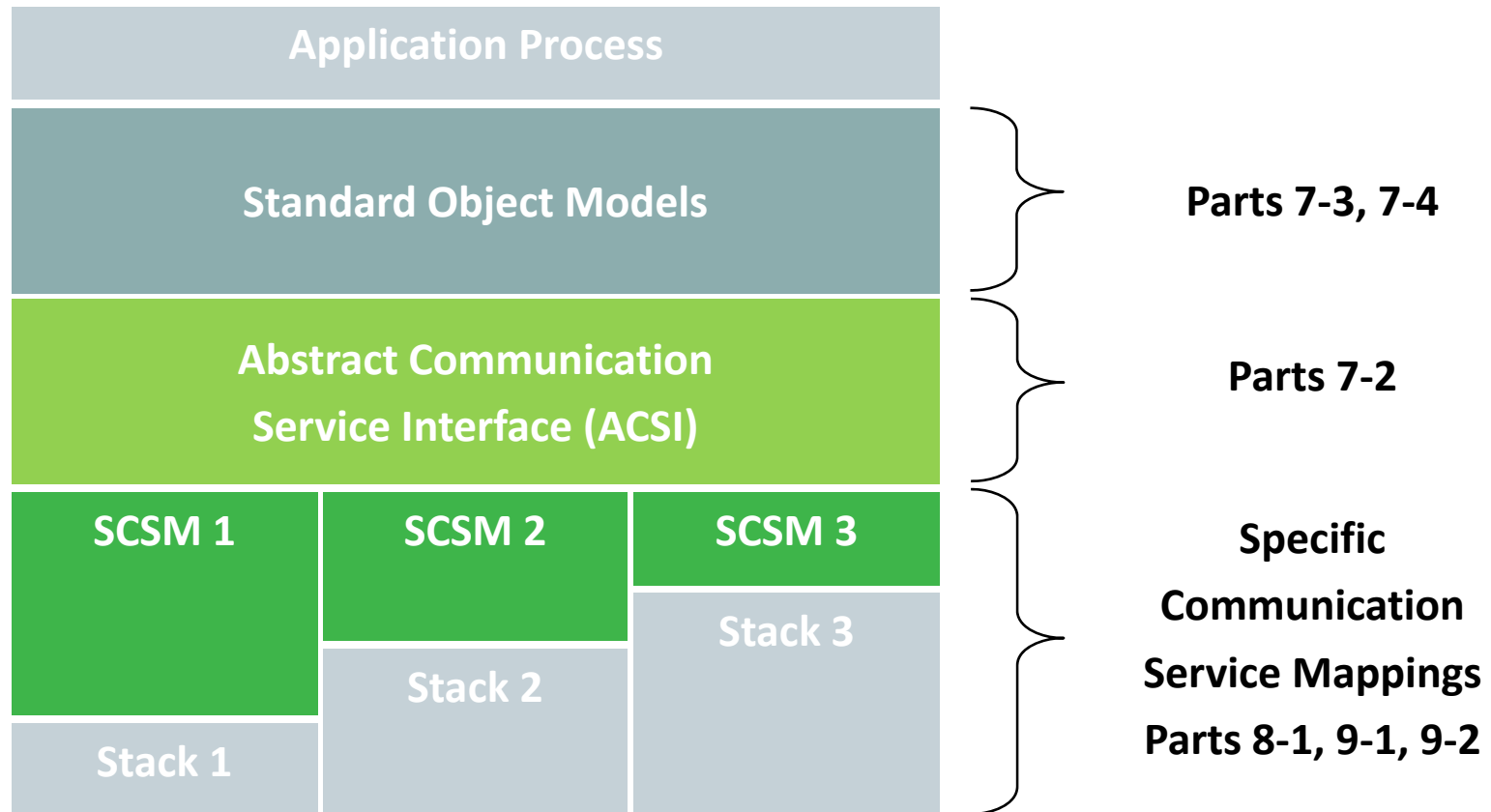


IEC 61850 STANDARD SERIES

- Multiple protocols to span functional areas
 - TCP/IP based client/server communication
 - Ethernet based GOOSE protocol for high-speed substation events
 - Ethernet based Sampled Values protocol for synchronized data streaming
- Provides framework for 'future proofing'
 - layered for future extensibility



IEC 61850 REFERENCE MODEL



THE CONTENTS OF IEC 61850

System Aspects Part 1: Introduction and Overview Part 2: Glossary Part 3: General Requirements Part 4: System and Project Management Part 5: Comm Requirements for Functions and Device Models	Data Models Basic Communication Structure for Substations and Feeder Equipment Part 7-4: Compatible Logical Node Classes and Data Classes Part 7-3: Common Data Classes
Configuration Part 6: Configuration Language for electrical Substation IED's	Abstract Comm. Services Basic Communication Structure for Substations and Feeder Equipment Part 7-2: Abstract Communication Services (ACSI) Part 7-1: Principles and Models
Testing Part 10: Conform. Testing	Mapping to real Comm. Networks (SCSM) Part 8-1: Mapping to MMS and ISO/IEC 8802-3 Part 9-1: Sampled Values over Serial Unidirectional Multidrop Point-to-Point link Part 9-2: Sampled Values over ISO/IEC 8802-3



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FEATURES OF IEC 61850

- Multiple Ethernet protocols
 - TCP/IP based communication for SCADA
 - Link layer Goose protocols for high speed multicast protection functions
 - Link layer Sampled Values protocol for high speed multicast streaming data
- Standardized models for all substation functions



FEATURES OF IEC 61850

- Standardized configuration language
 - Substation network and power system topology
 - Device level interface descriptions
 - Device level settings and addressing
- Self-description for validating entire substation

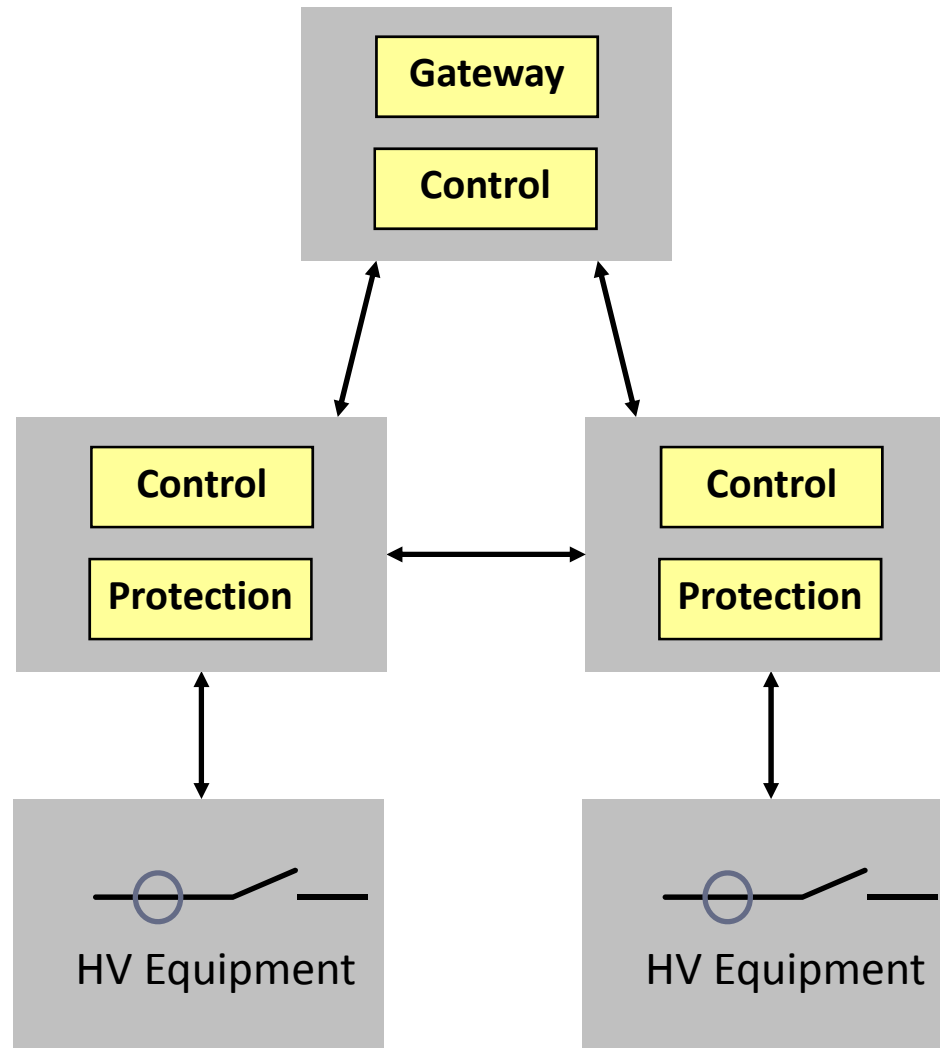


IEC 61850 PROTOCOLS

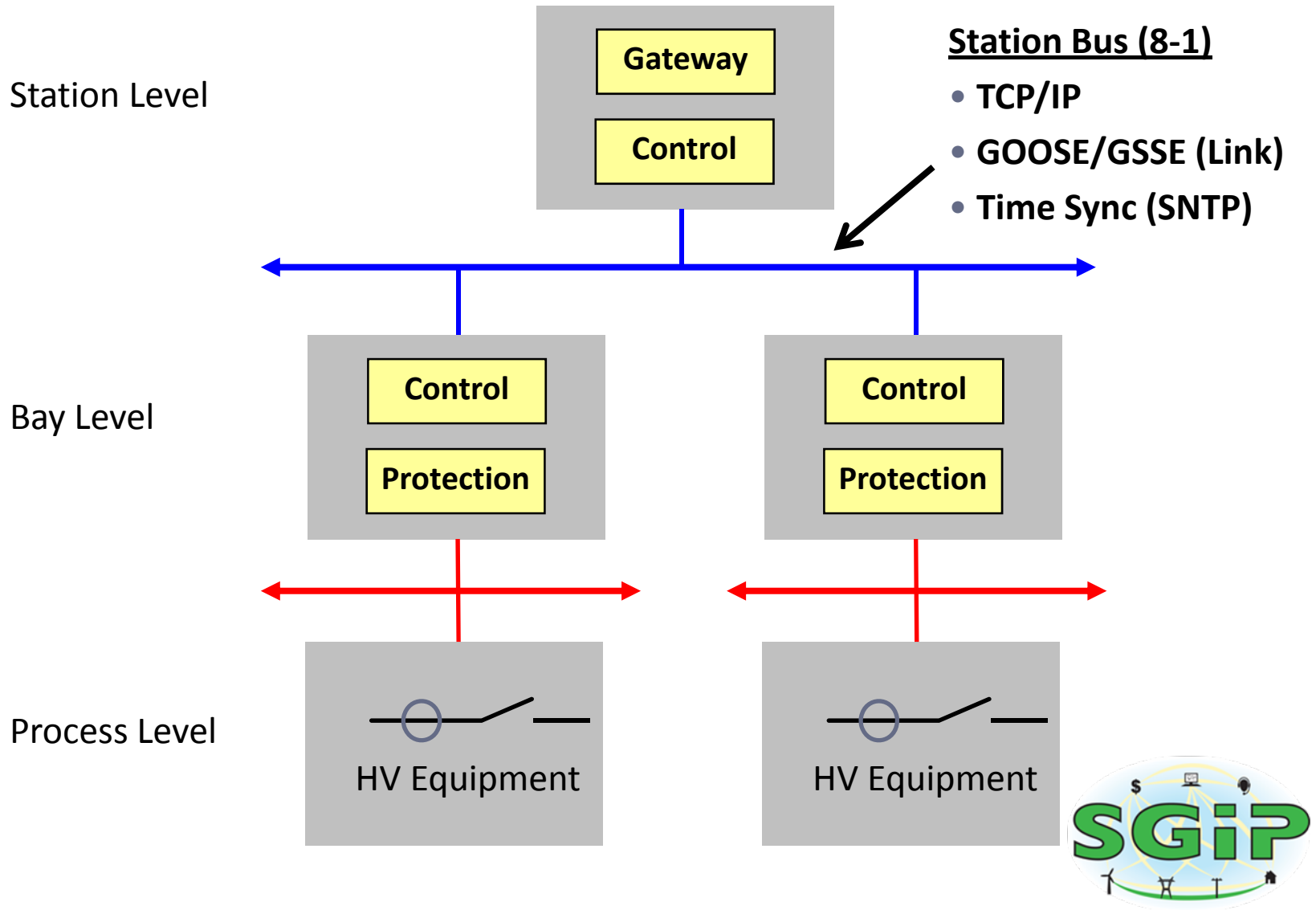
Station Level

Bay Level

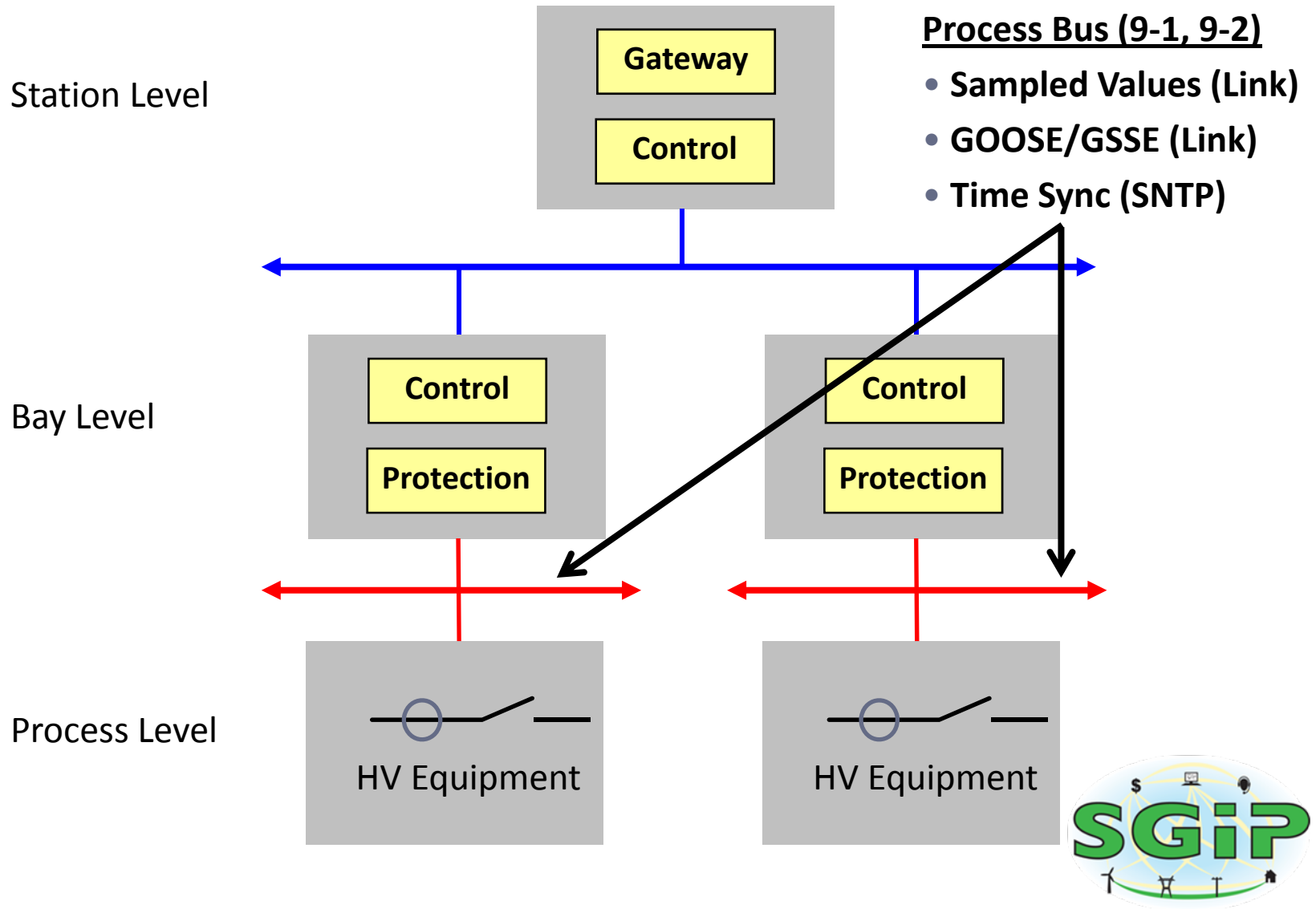
Process Level



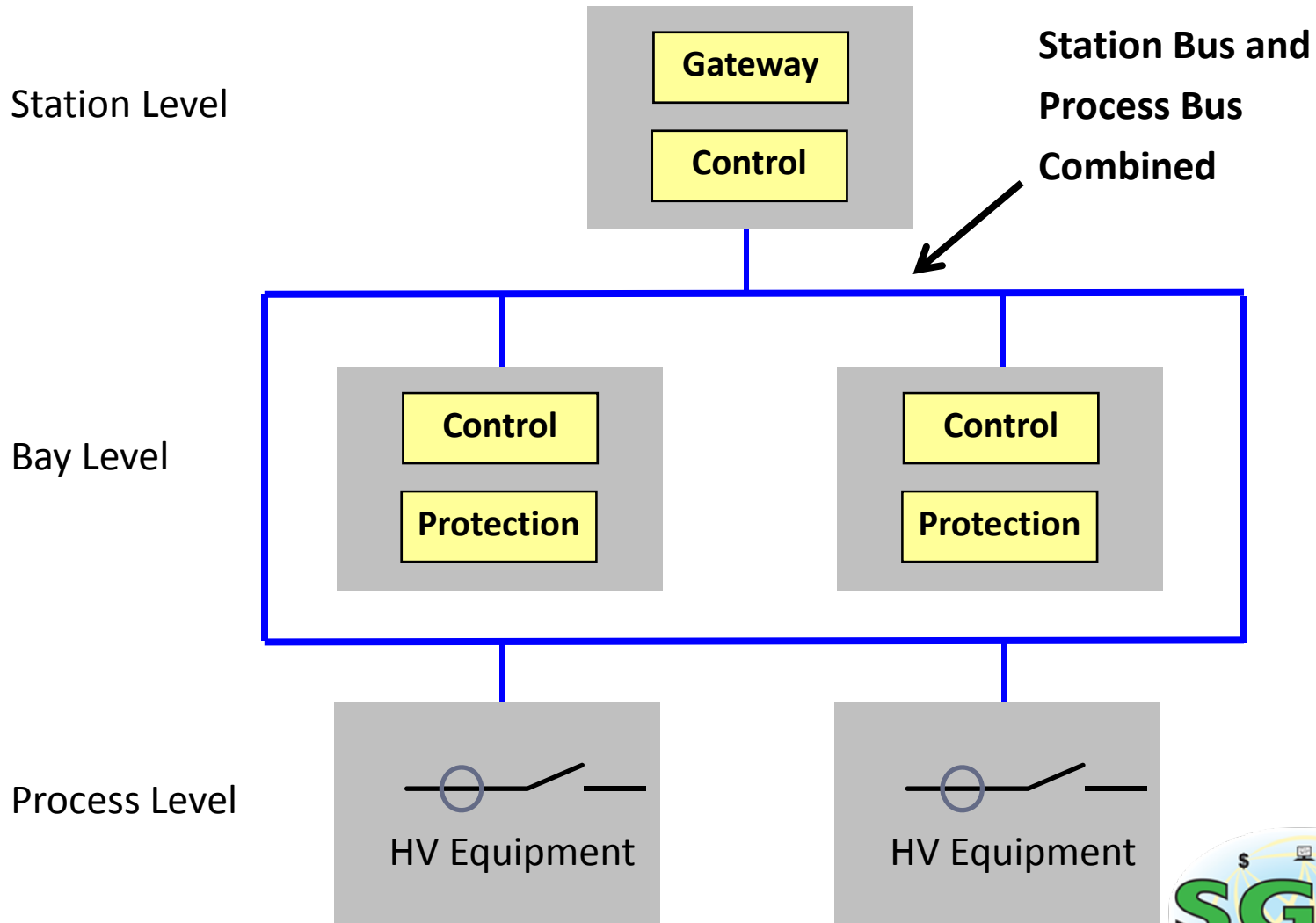
IEC 61850 PROTOCOLS



IEC 61850 PROTOCOLS



IEC 61850 PROTOCOLS



MODELS – LN CLASS GROUPS

LN Group	Functions
L	System Logical Nodes
A	Automatic Control
C	Supervisory Control
G	Generic Function References
I	Interfacing and Archiving
M	Metering and Management
P	Protection Functions
R	Protection Related Functions
S	Sensors and Monitoring
T	Instrument Transformers
X	Switchgear
y	Power Transformer and Related Functions
Z	Other Power System Equipment



MODELS – EXAMPLE LNs

LN Class	Function
XCBR	Circuit Breaker
CSWI	Switch Controller
CPOW	Point on Wave Switching
CILO	Interlocking Control
MMXU	Measurement Unit
PDIS	Distance Relay
PTOC	Time Overcurrent
RDRE	Disturbance Recorder
MDIF	Differential Measurements



SUBSTATION CONFIGURATION LANGUAGE

- XML based language for configuring substations and substation devices
- Designed for exchange of information between engineering tools
- Includes descriptions of device models, communication infrastructure, and relationships with the power system



SUBSTATION CONFIGURATION LANGUAGE

- Configure clients and databases
- Assign addresses and settings for all IEDs
- Support for SCL required for conformance to IEC 61850



PARTS OF AN SCL FILE

- Header

- Documents source and change history, etc.

- Substation

- Describes functional structure of substation
 - Primary devices and electrical connections
 - May associate logical nodes with equipment

- Communications

- Subnetworks, access points, clocks, and routers
 - Associates clients and servers with access points



PARTS OF AN SCL FILE

- IED

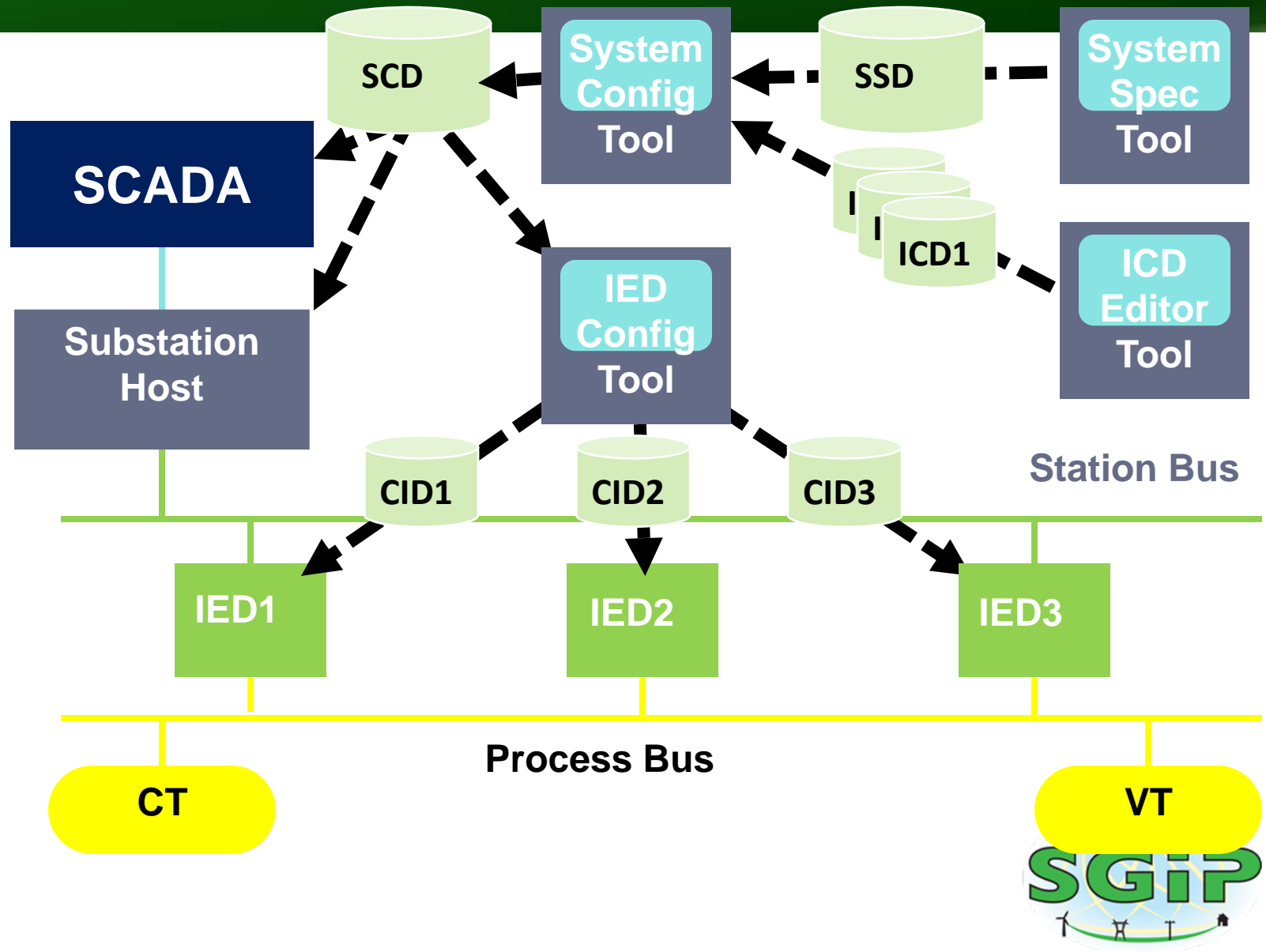
- Defines communication servers and their access points
- Defines capabilities, logical devices, and their logical nodes and configuration setting values

- Data Type Templates

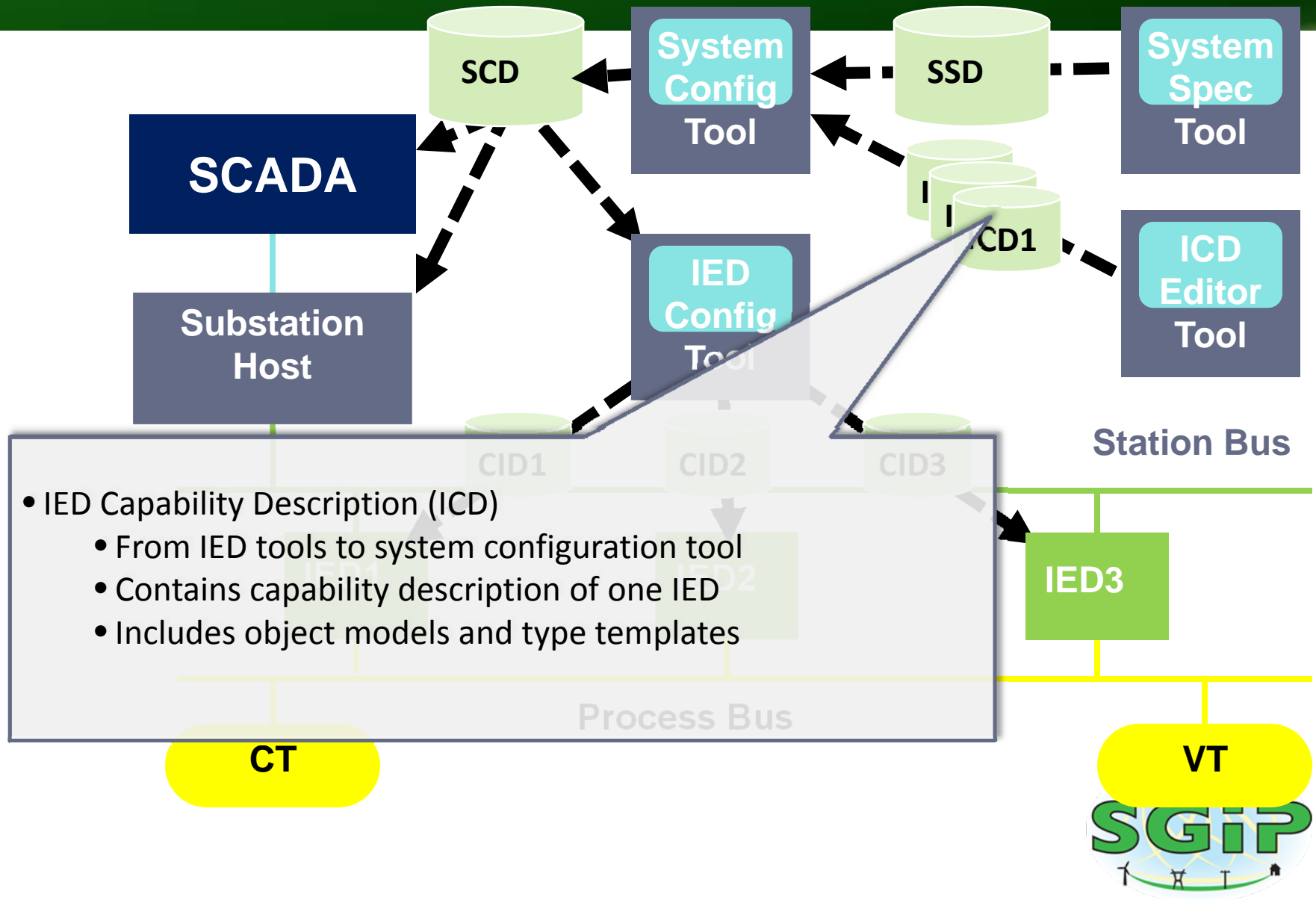
- Describes full definitions of all logical nodes, data objects, and data types



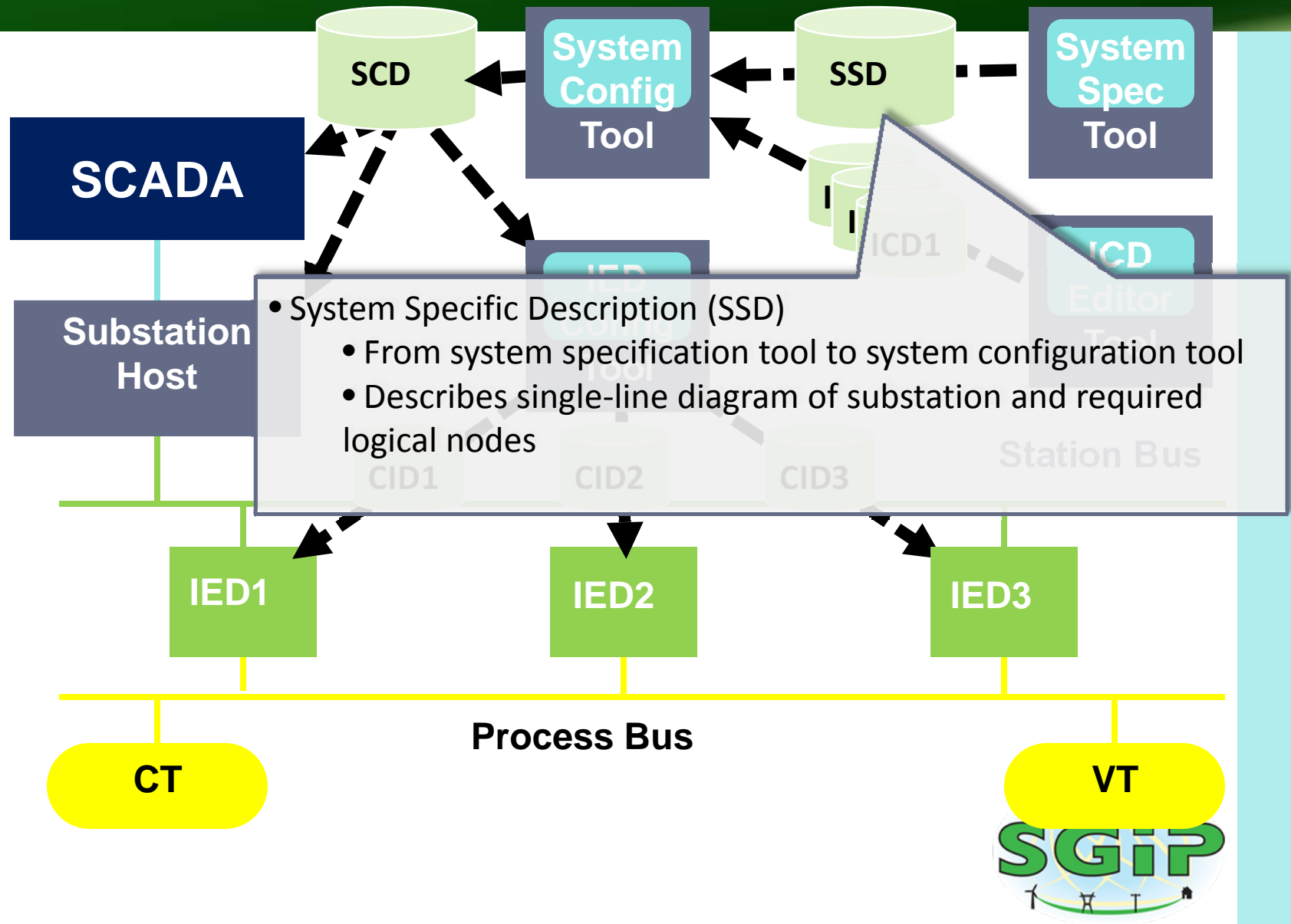
61850 SCL FILE USAGE



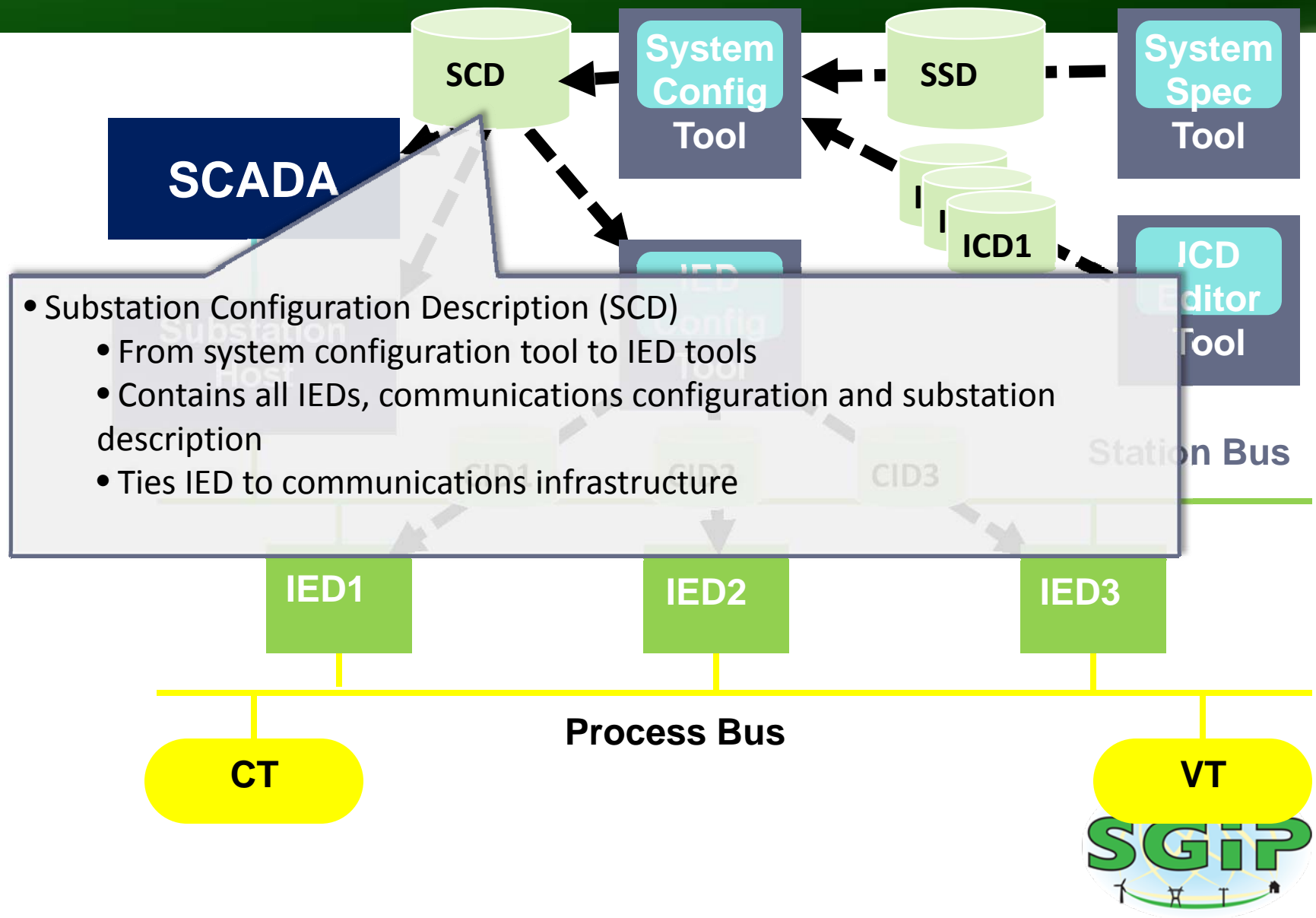
61850 SCL FILE USAGE



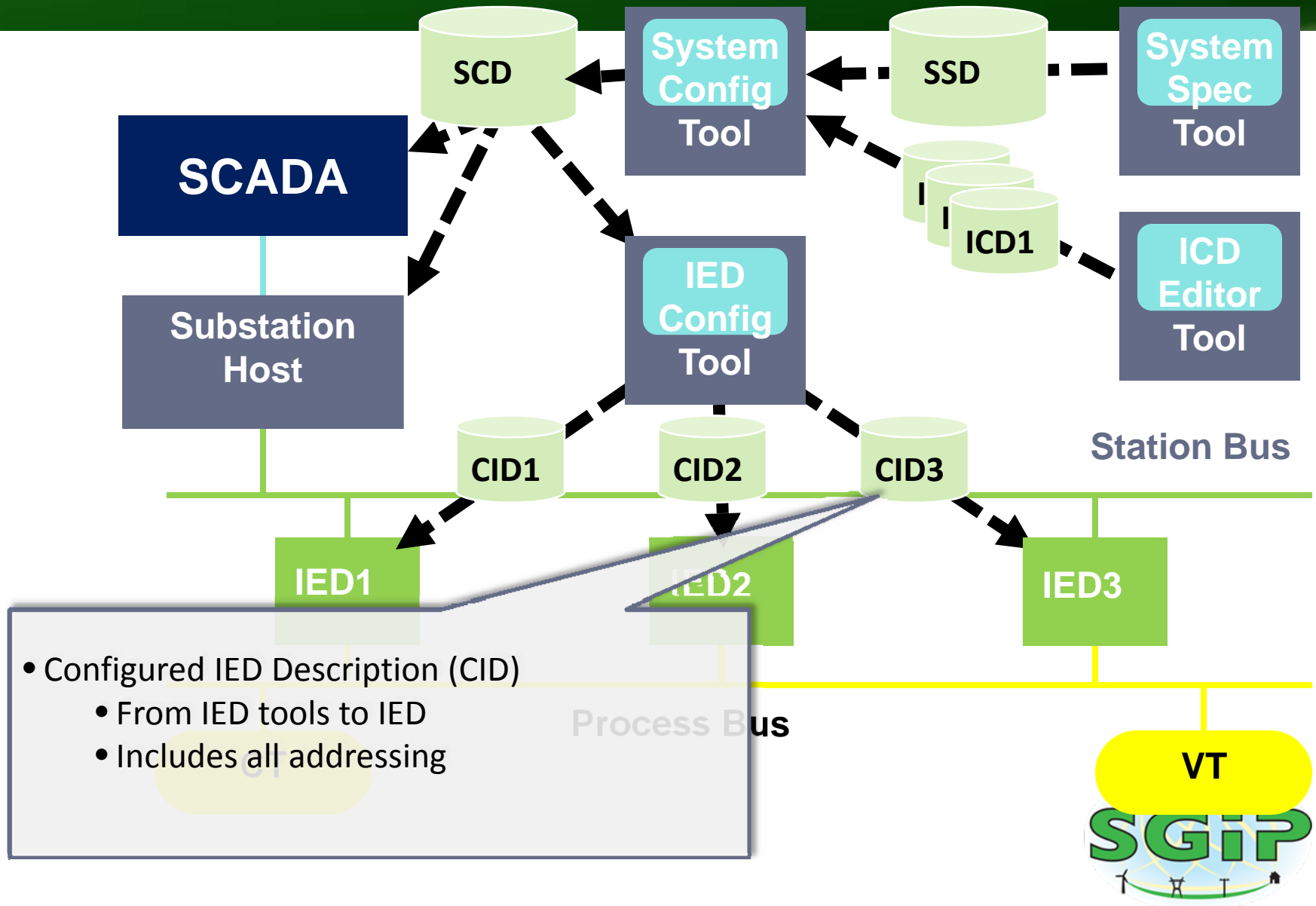
61850 SCL FILE USAGE



61850 SCL FILE USAGE



61850 SCL FILE USAGE



SELF DESCRIPTION

- Clients have complete descriptions via SCL
 - IED data models
 - IED settings
 - IED addresses and connectivity
 - Goose and Sampled Value streams
- Each IED has complete description available through ACSI services
- Each client can validate servers against SCL configuration



IEC 61850 SECURITY

- Revision 1 (2003) had only password authentication
- Revision 2 (expected 2010) makes use of IEC 62351
 - TC57 common security framework
 - Includes TLS at transport
 - Includes authentication and encryption at application layer
 - Includes encryption for Goose, and Sampled Values
 - Certificate management and revocation described in 62351, but management without CA still under discussion
- Revision 3 will add Role-Based Access Control



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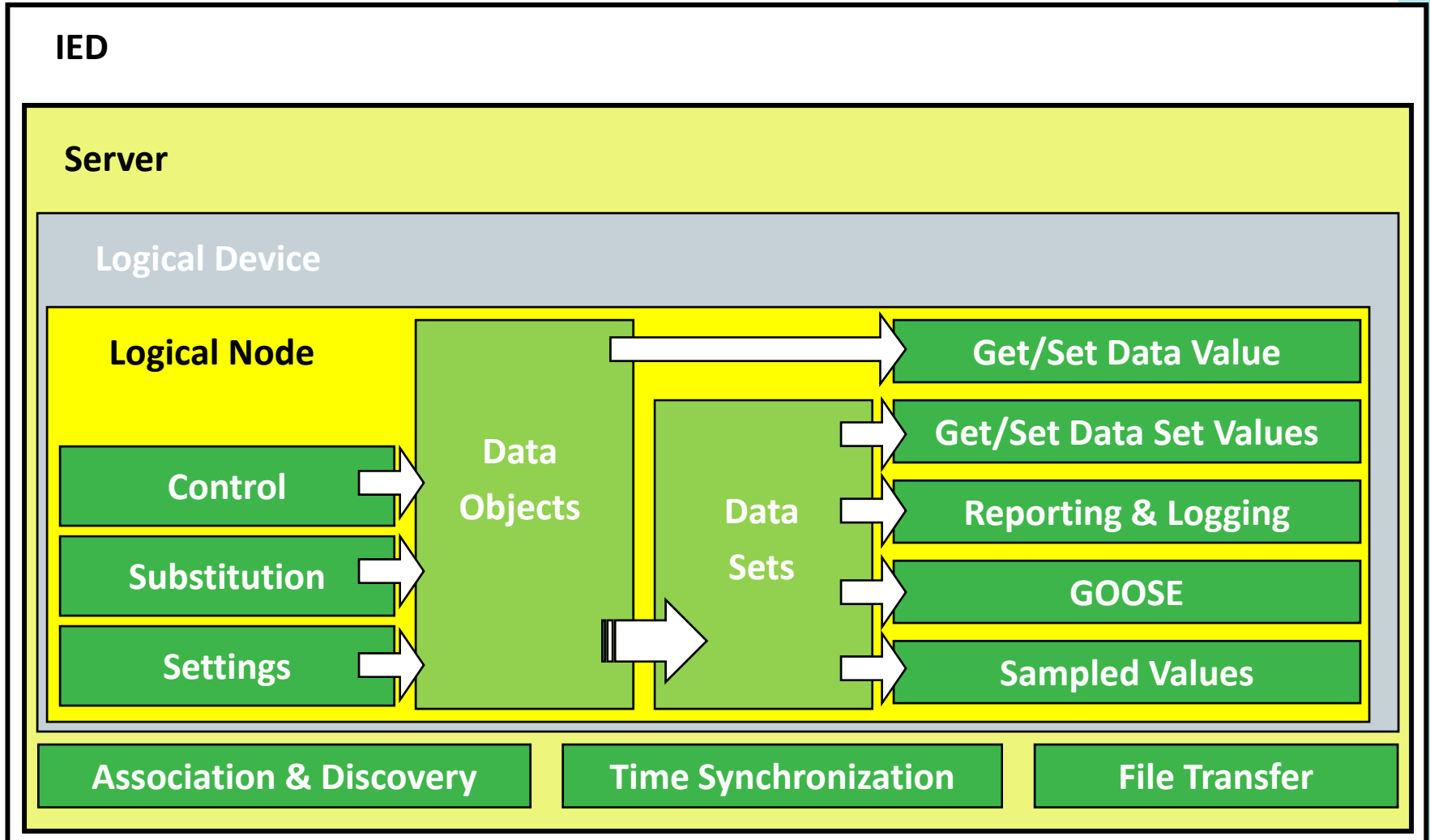
APPLICATION MODELING

- Logical nodes as the core components of the object model
- The hierarchical object model
- Specification of logical nodes and common data classes
- The configuration language

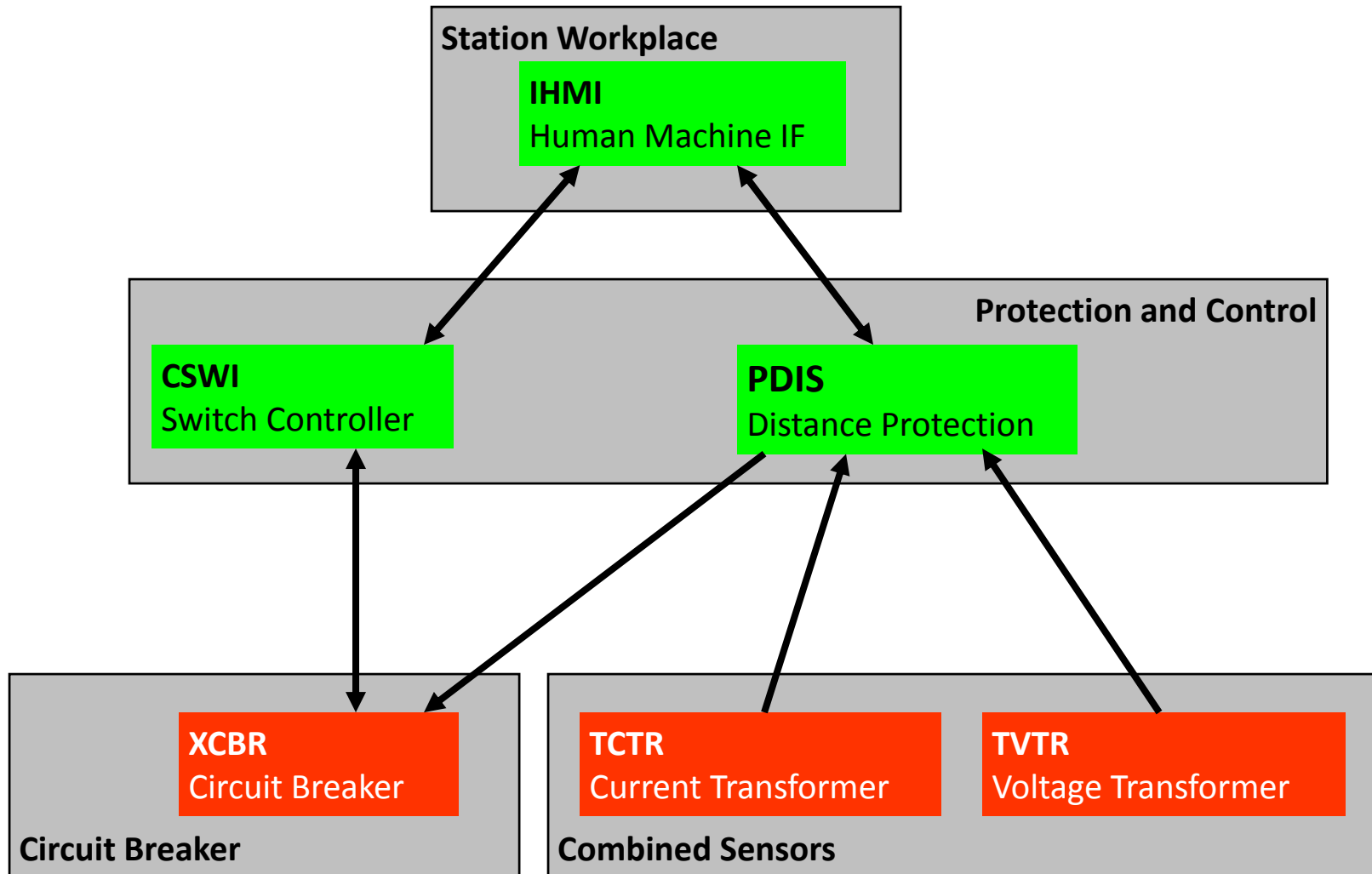


ACSI MODELS

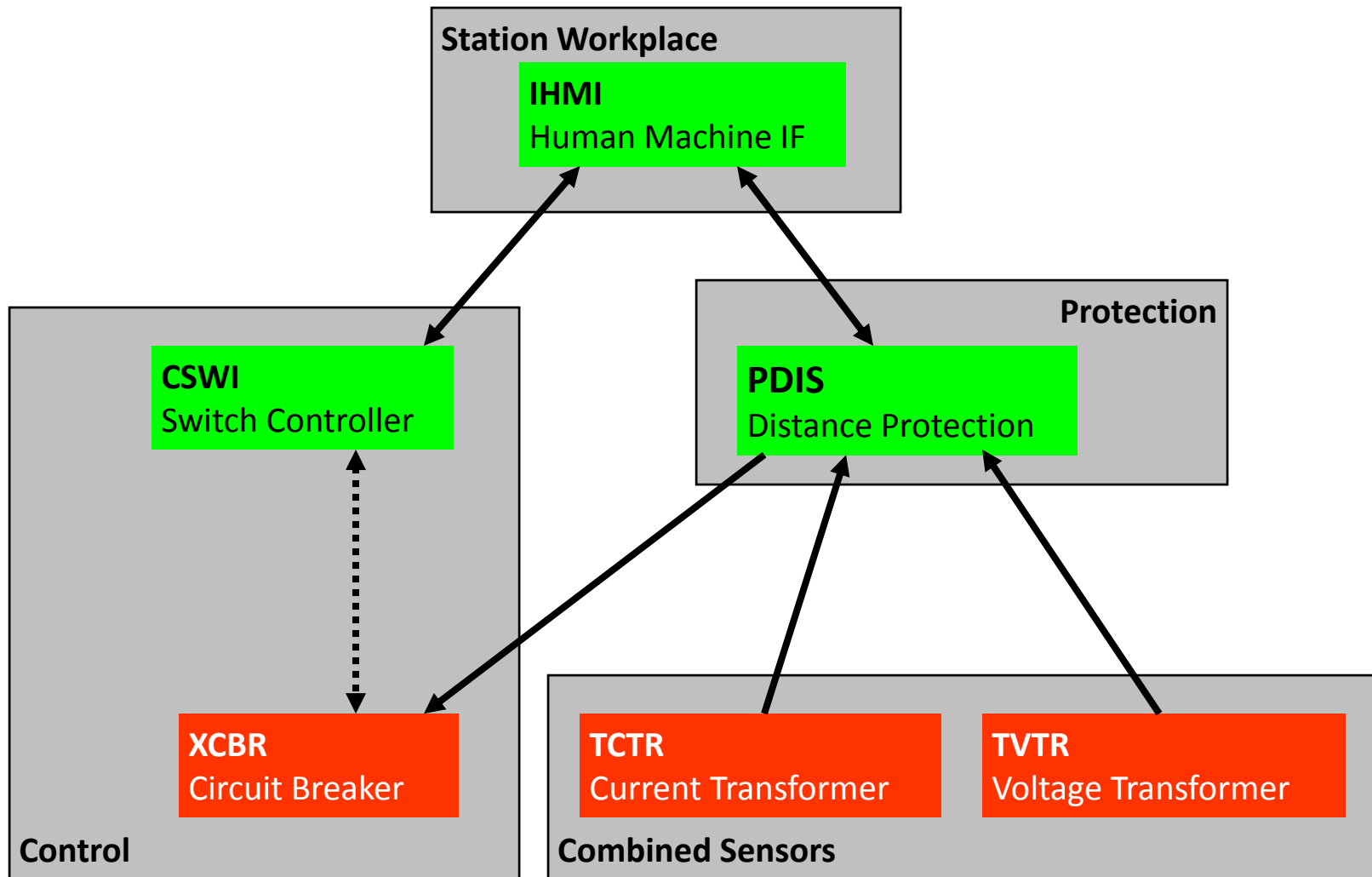
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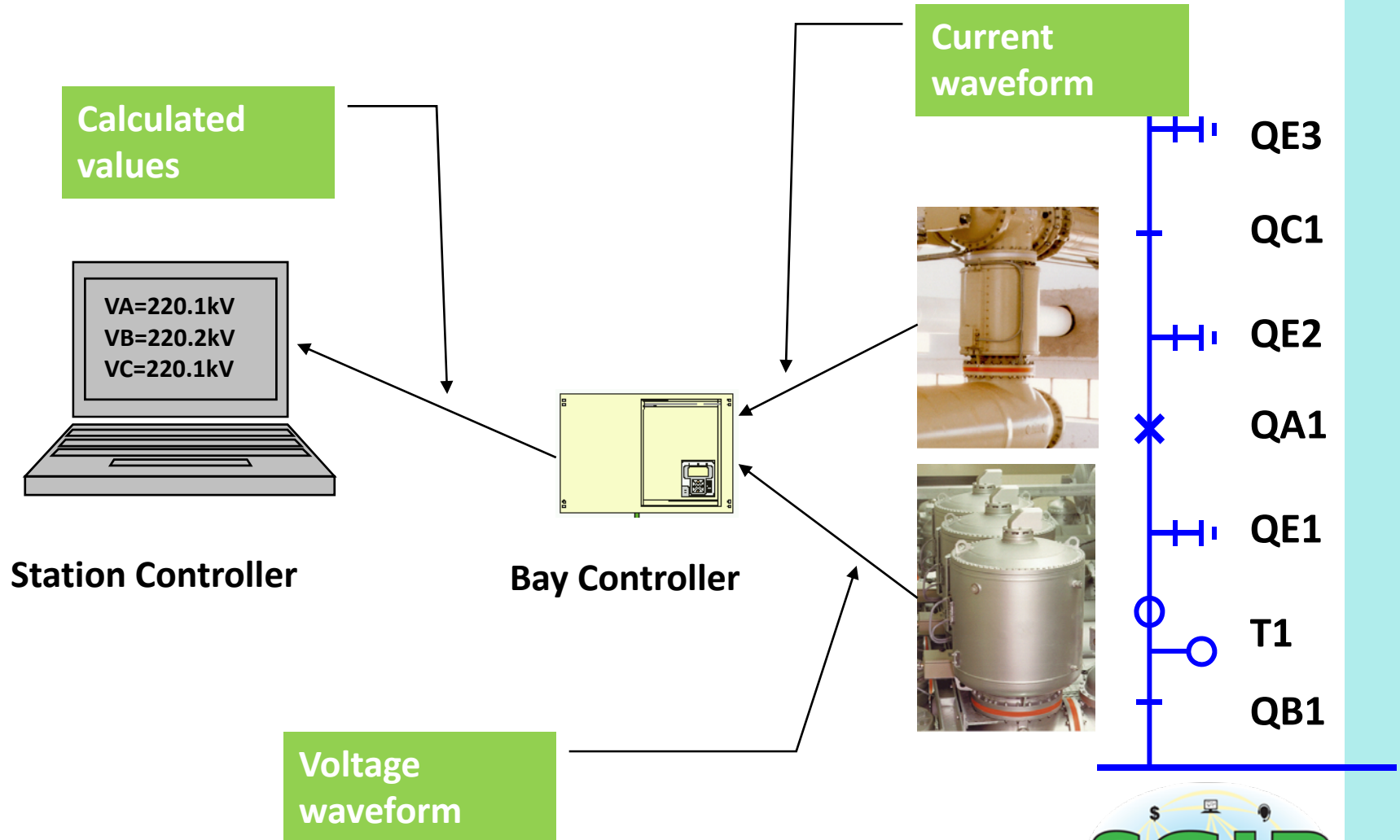
LOGICAL NODES AND DEVICES



LOGICAL NODES AND DEVICES

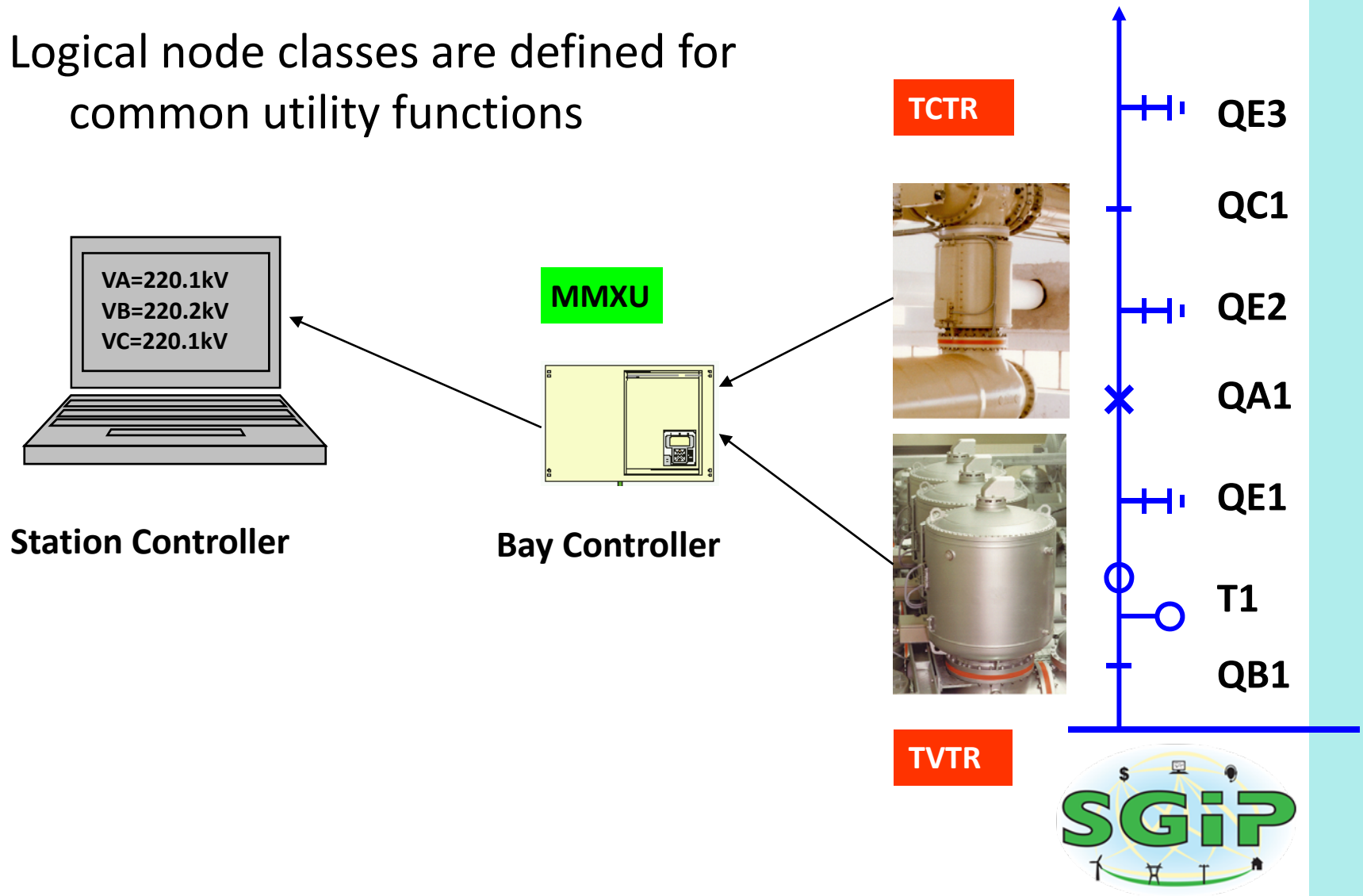


EXAMPLE USING IEC 61850



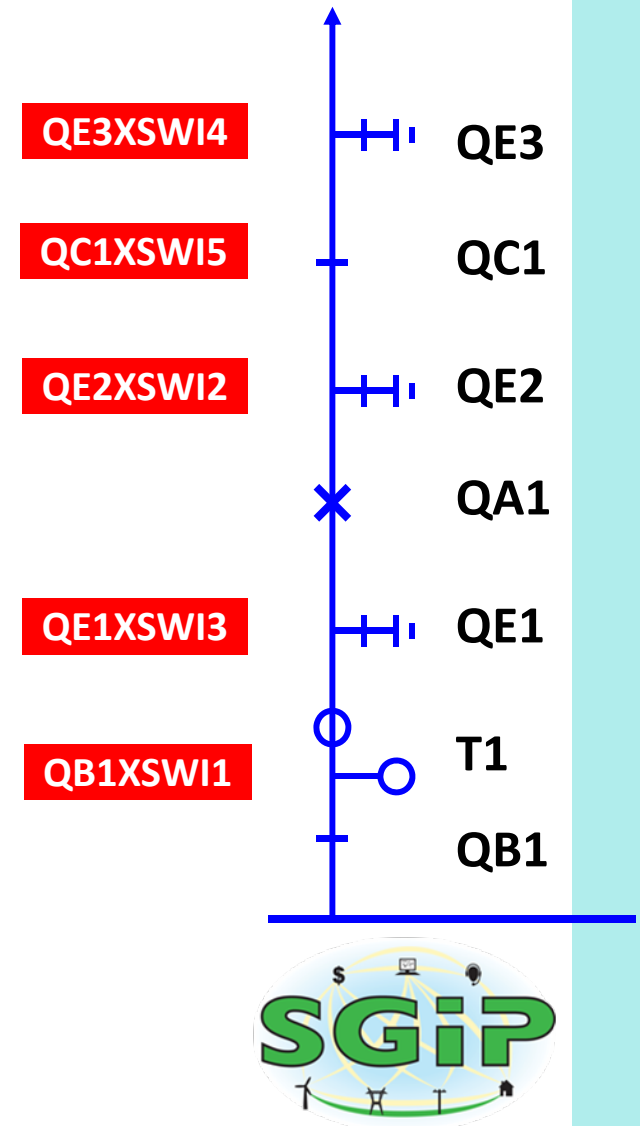
THE DATA MODEL — LOGICAL NODES

Logical node classes are defined for common utility functions



THE DATA MODEL – LOGICAL NODES

- The names of logical nodes (e.g. XSWI) are standardized in IEC 61850-7-4 and have always four characters
- The name of an instance of a logical node may have a prefix and a suffix
- Names should correspond to local utility designation



COMMON DATA CLASSES

- Logical Nodes contain data objects, each defined in terms of a Common Data Class
- CDCs define a Data Attributes for each object
 - Status and control values
 - Configuration settings
 - Range and limit specifications
 - Descriptions and class information
- CDC descriptions define mandatory and optional data attributes



EXAMPLE – LN TCTR CLASS

Attribute	Type	Explanation	M/O
Amp	SAV	Current (Sampled value)	O
ARtg	ASG	Rated Current	O
HzRtg	ASG	Rated Frequency	O
Rat	ASG	Winding Ratio	O
Cor	ASG	Current Phasor magnitude correction	O
AngCor	ASG	Current Phasor angle correction	O



EXAMPLE – SAV CDC

Attribute	Type	FC	TrgOp	MJ/O
InstMag	AnalogueValue	MX	dchg	M
q	Quality	MX	qchg	M
t	TimeStamp	MX		O
Units	Unit	CF		O
sVC	ScaledValueConfig	CF		O
Min	AnalogueValue	CF		O
Max	AnalogueValue	CF		O

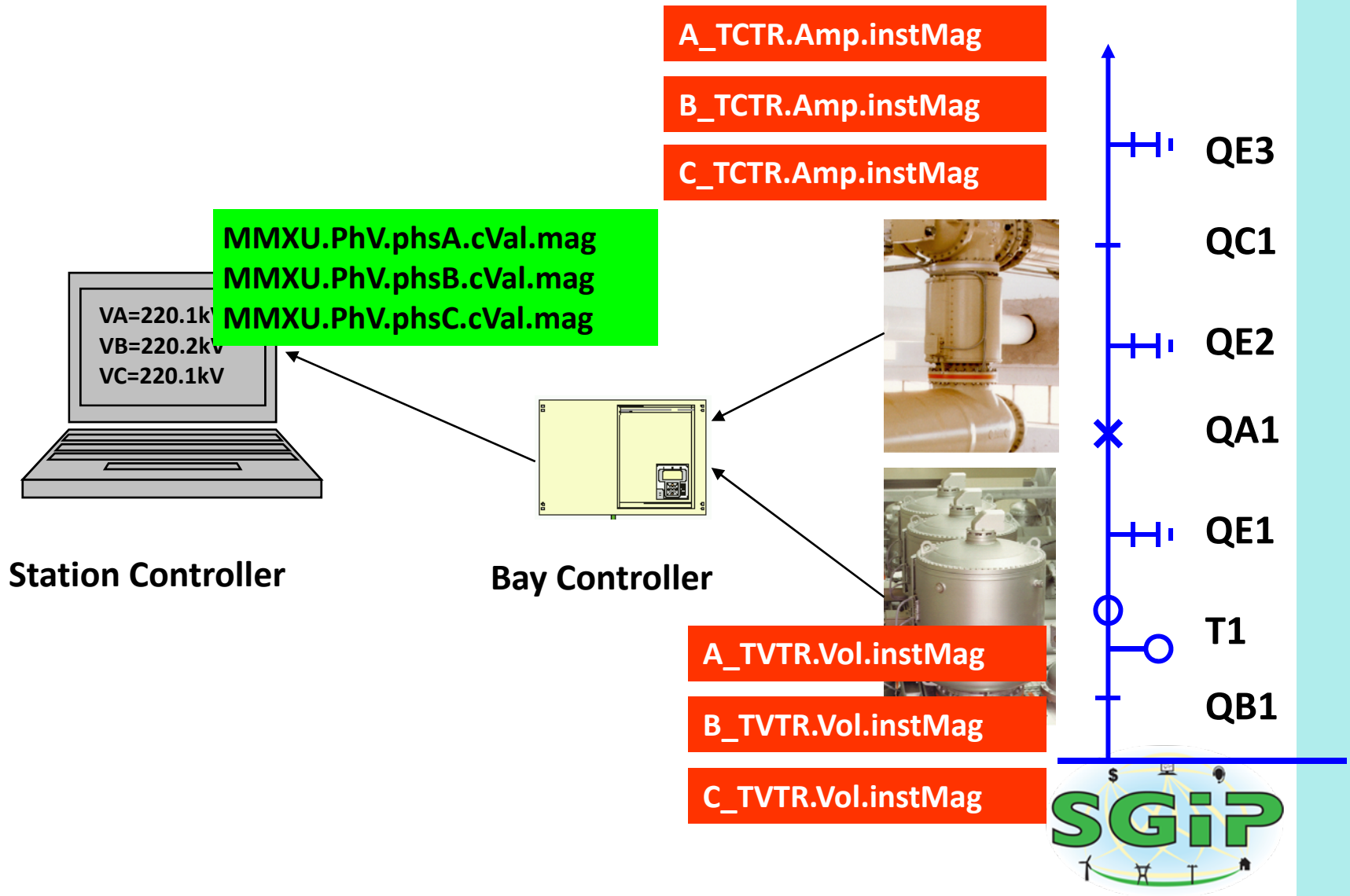


EXAMPLE – ANALOGUEVALUE CDC

Attribute	Type			M/O
i	INT32			Note
f	FLOAT32			Note



DATA AND DATA ATTRIBUTES



LOGICAL NODES AND DATA



XSWI

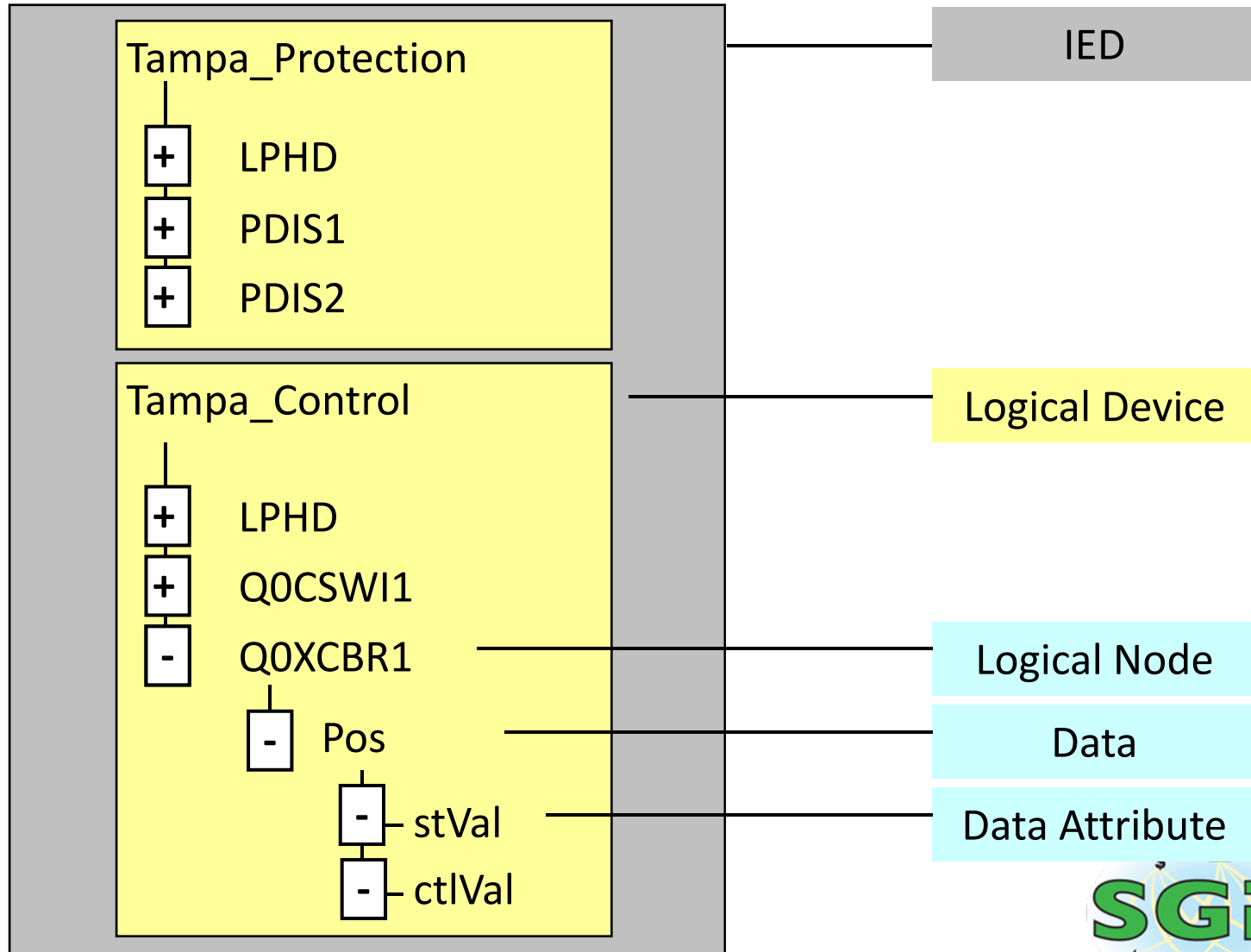
optional /
mandatory

Data Name	Type	Explanation	
Mod	INC	enable / disable mode	M
Loc	SPS	Local / remote control	M
EEHealth	INS	ok / warning / alarm	O
EEName	DPL	Name plate	O
OpCnt	INS	Operation counter	O
Pos	DPC	position	M
BlkOpn	SPC	block opening	M
BlkCls	SPC	block closing	M
SwTyp	INS	load break, dis, earth..	O
PosSenAl	SPS	pos sensor alarm	

Extension (own Namespace)



HIERARCHICAL DATA MODEL

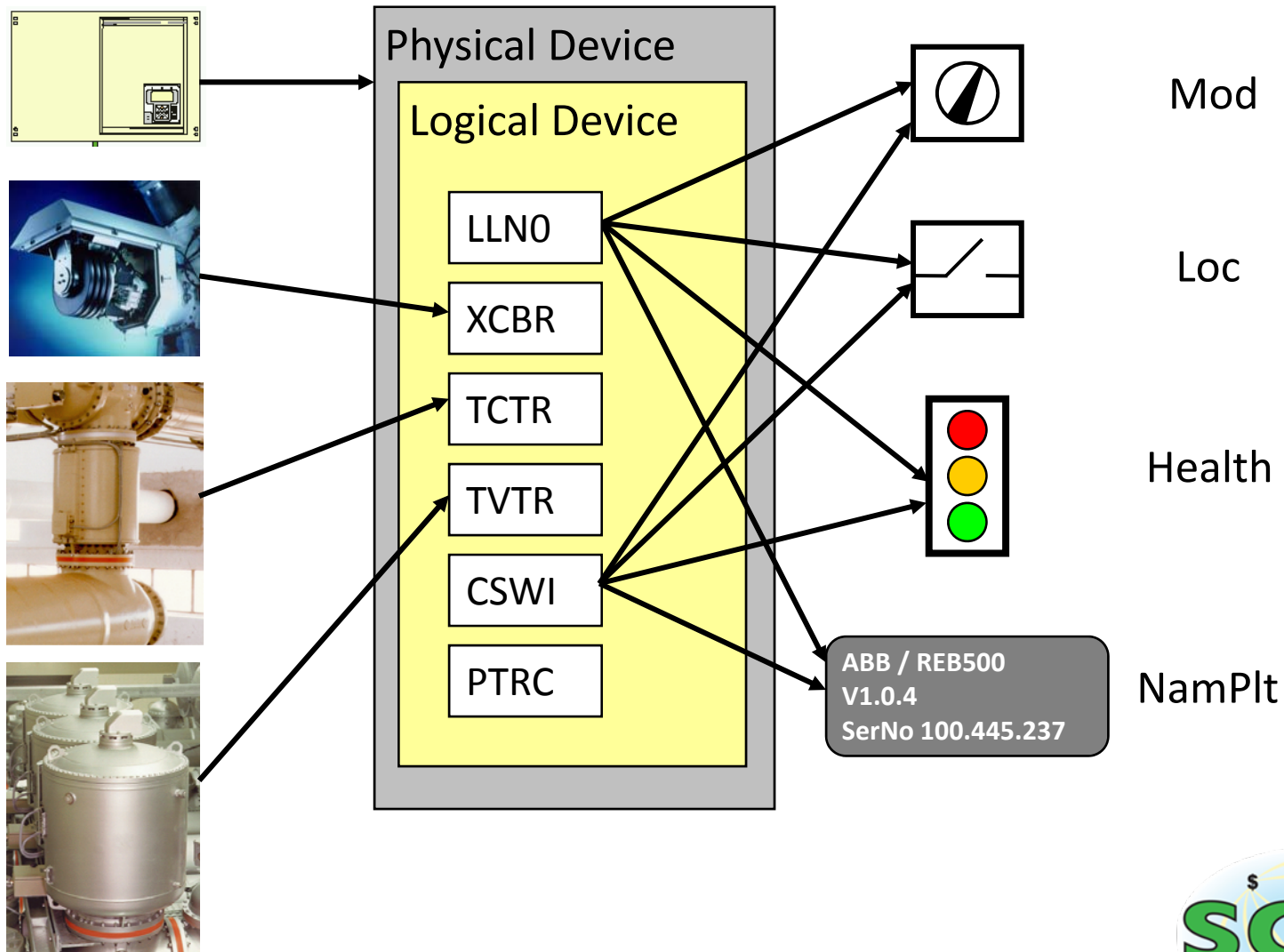


DEVICE MANAGEMENT INFORMATION

- All Logical Nodes contain specific status and controls for management
 - Mod – mode setting (e.g. on, off, test, blocked)
 - Loc – local/remote switch status
 - Health – functional status (e.g. ok, warning, alarm)
 - NamPlt – nameplate identification
- Special LN LLN0 contains management status and controls for the overall logical device



DEVICE MANAGEMENT INFORMATION



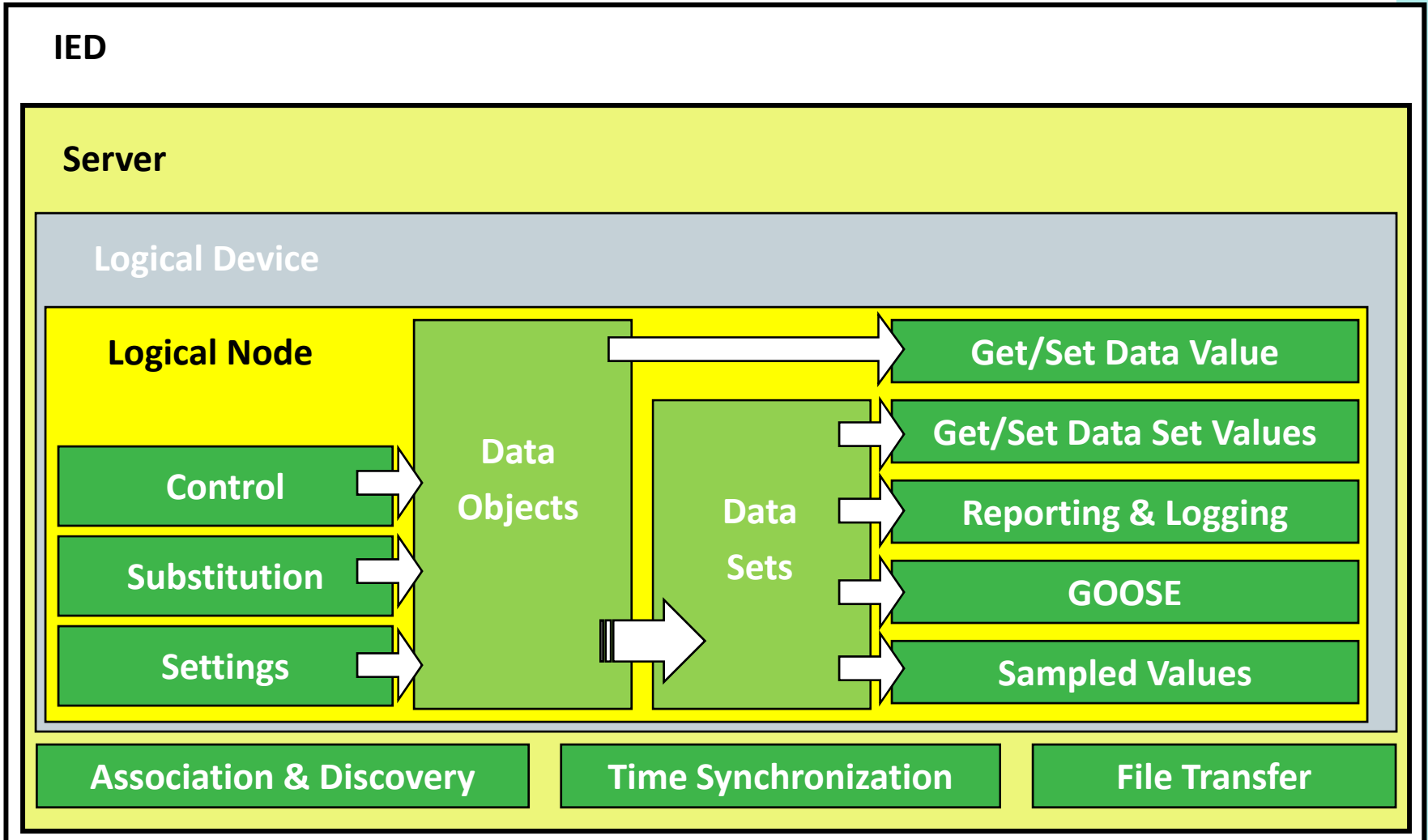
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ACSI MODELS

IED



IEC 61850 SERVICES OVERVIEW

- Control Models
- Substitution Models
- Settings Group Controls
- Reporting and Logging
- Goose
- Sampled Values
- Other Services



CONTROL MODEL

- Applies to object types:
 - Controllable Single and Double points
 - Binary and Analog Controlled Step Position
 - Analog Set Point
- Immediate and Time Activated Operation



CONTROL MODEL

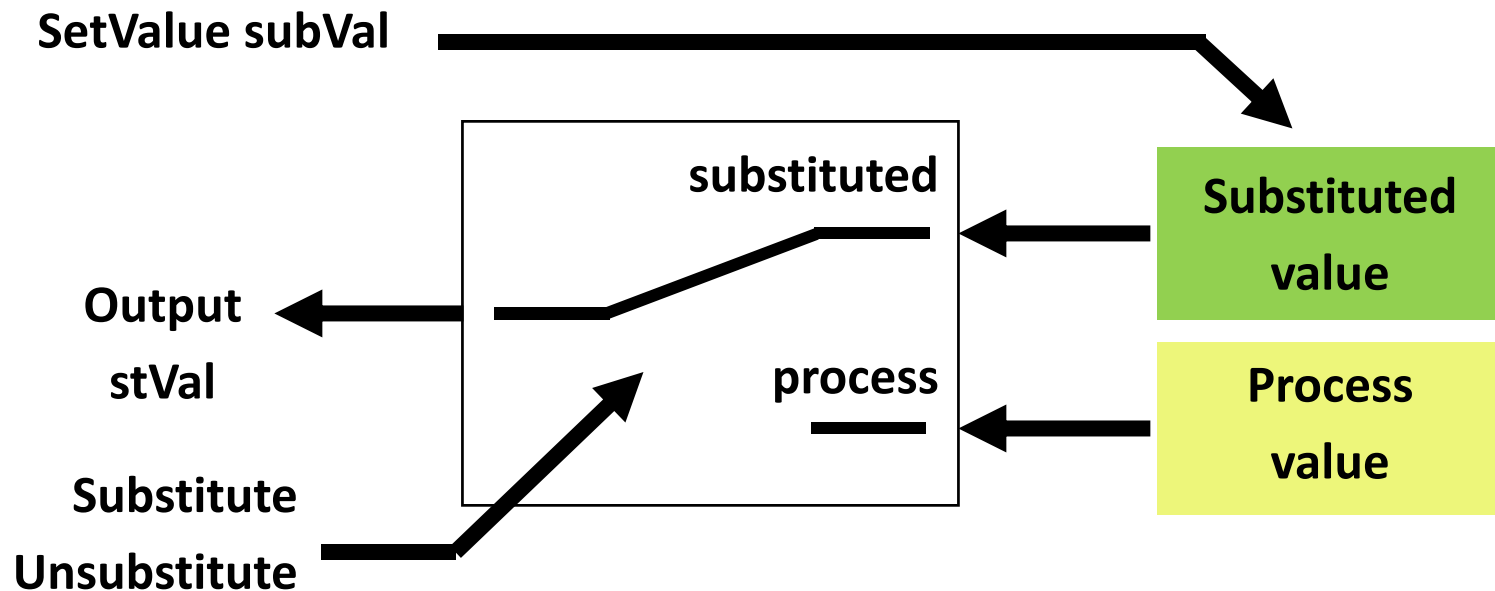
- Four control models defined

- Direct Control with Normal Security
 - Simple write of data
- Direct Control with Enhanced Security
 - Write of data, with termination report
- SBO Control with Normal Security
 - Simple select, then write of data
- SBO Control with Enhanced Security
 - Select with all control parameters for checks, then write of data



SUBSTITUTION MODEL

- Applies to status or measured data
- Selects preset value or process value
- Changes both value and quality

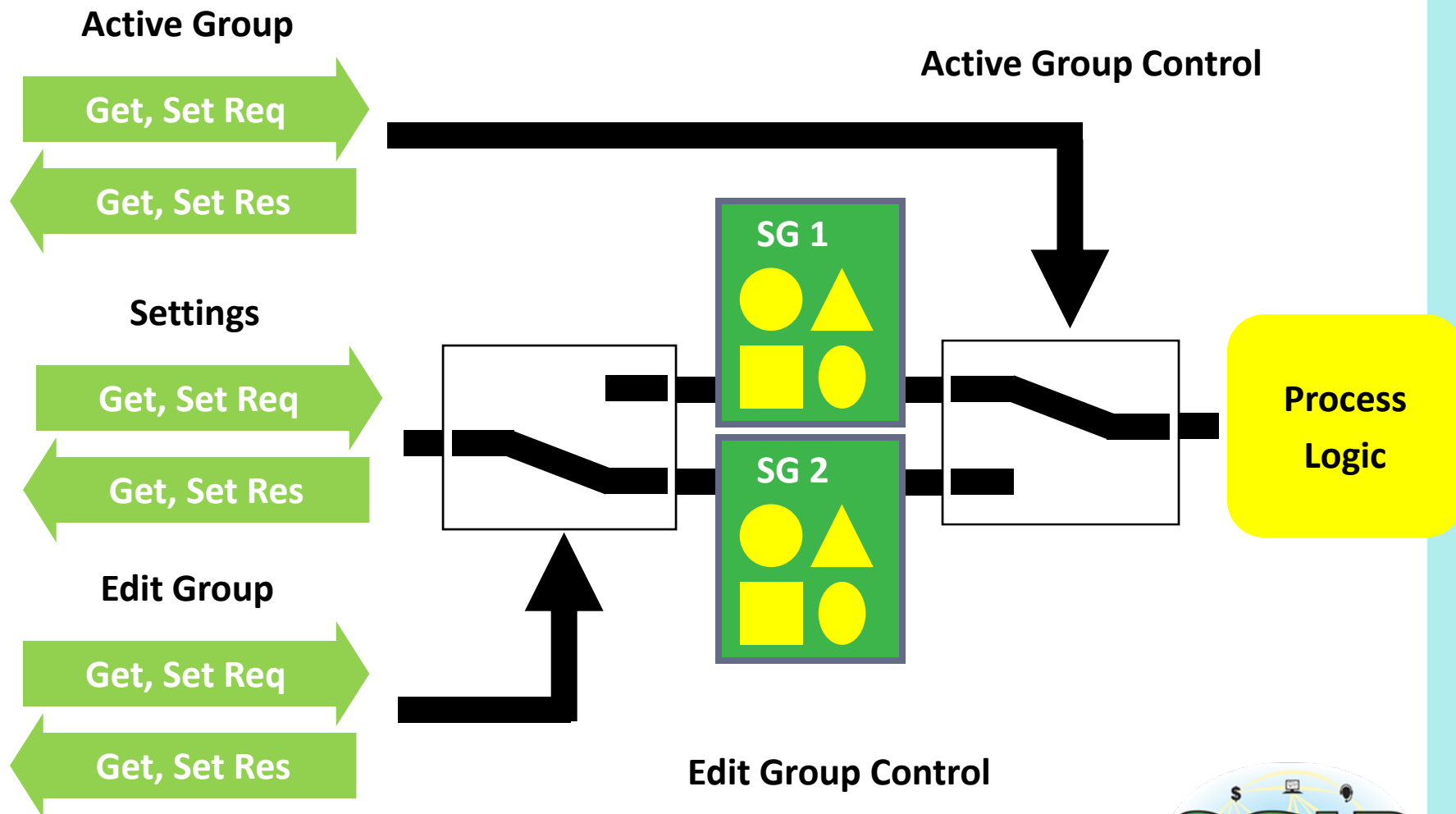


SETTINGS GROUP MODEL

- Settings Groups allow for simultaneous switching of multiple parameters
 - multiple copies of each parameter
 - exactly one copy of each is active
 - exactly one copy of each is editable



SETTINGS GROUP MODEL

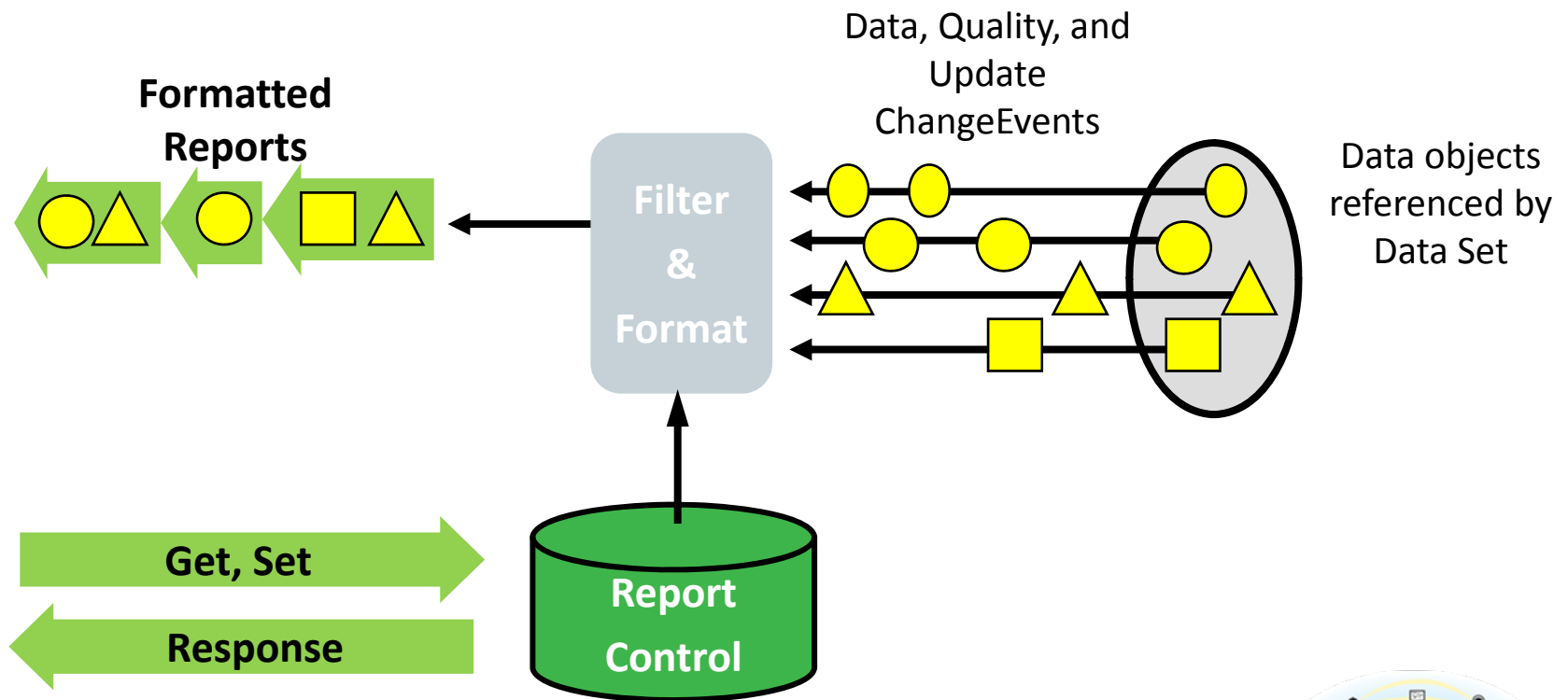


REPORTING MODEL

- Reports members of data sets
 - by exception, triggered by data, quality changes and/or freeze
 - periodic integrity report
 - multiple clients, multiple data sets
- Buffered and Unbuffered modes
- Various formats of reports to preserve bandwidth



UNBUFFERED REPORTING MODEL



UNBUFFERED REPORTING MODEL

- Operates over TCP connection oriented transport
- Clients control stream through control blocks
 - Select datasets and event trigger conditions
 - Select various report contents

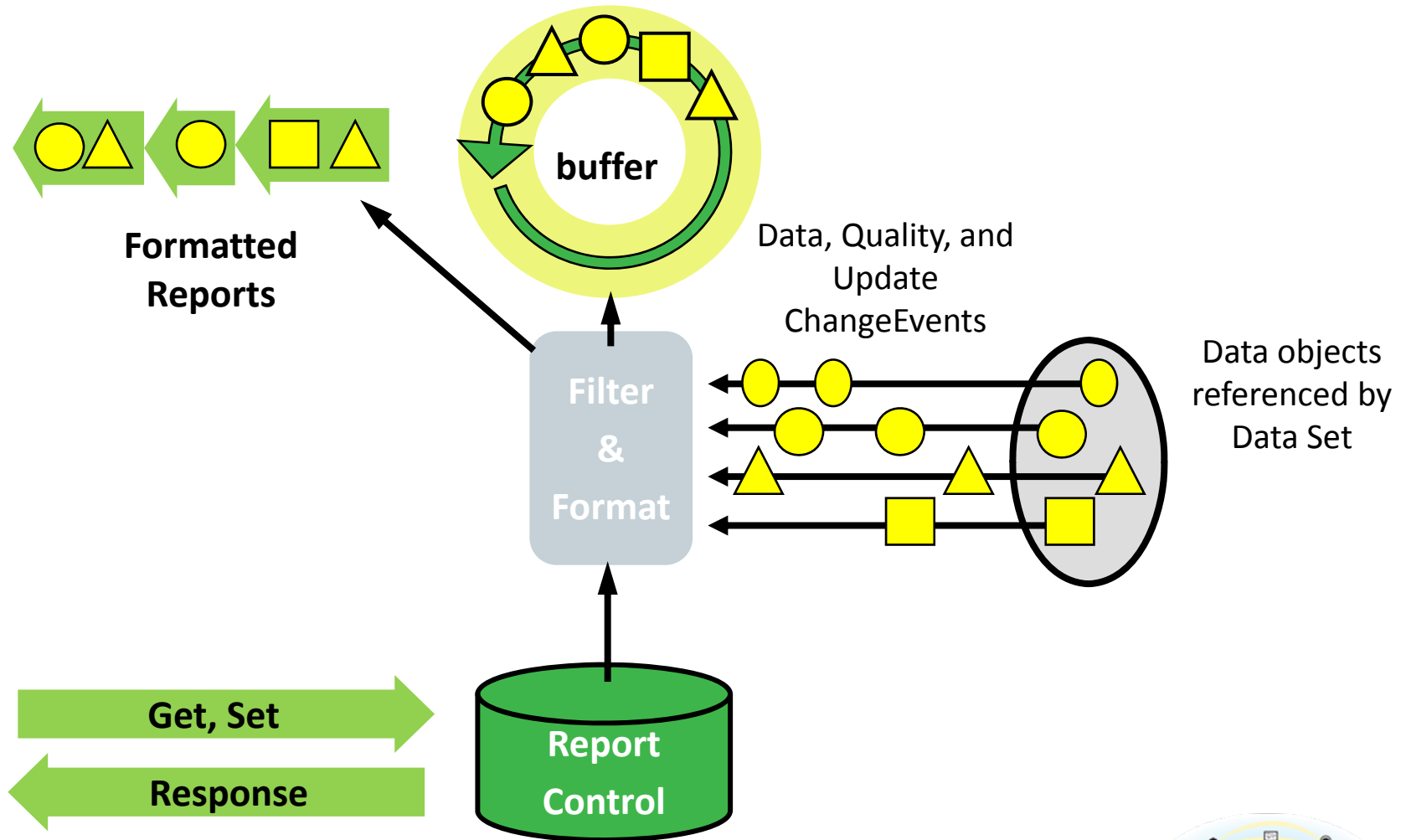


UNBUFFERED REPORTING MODEL

- Reports may also contain:
 - Timestamp
 - Sequence number
 - Reason for reporting
 - Object name or position in dataset
- Multiple control blocks allow for multiple clients and connections



BUFFERED REPORTING MODEL



BUFFERED REPORTING MODEL

- Same formats and options as unbuffered
- Buffering continues after loss of client connections
 - Includes mechanism for resynchronizing on reconnect
 - Includes mechanism for signaling buffer overflow

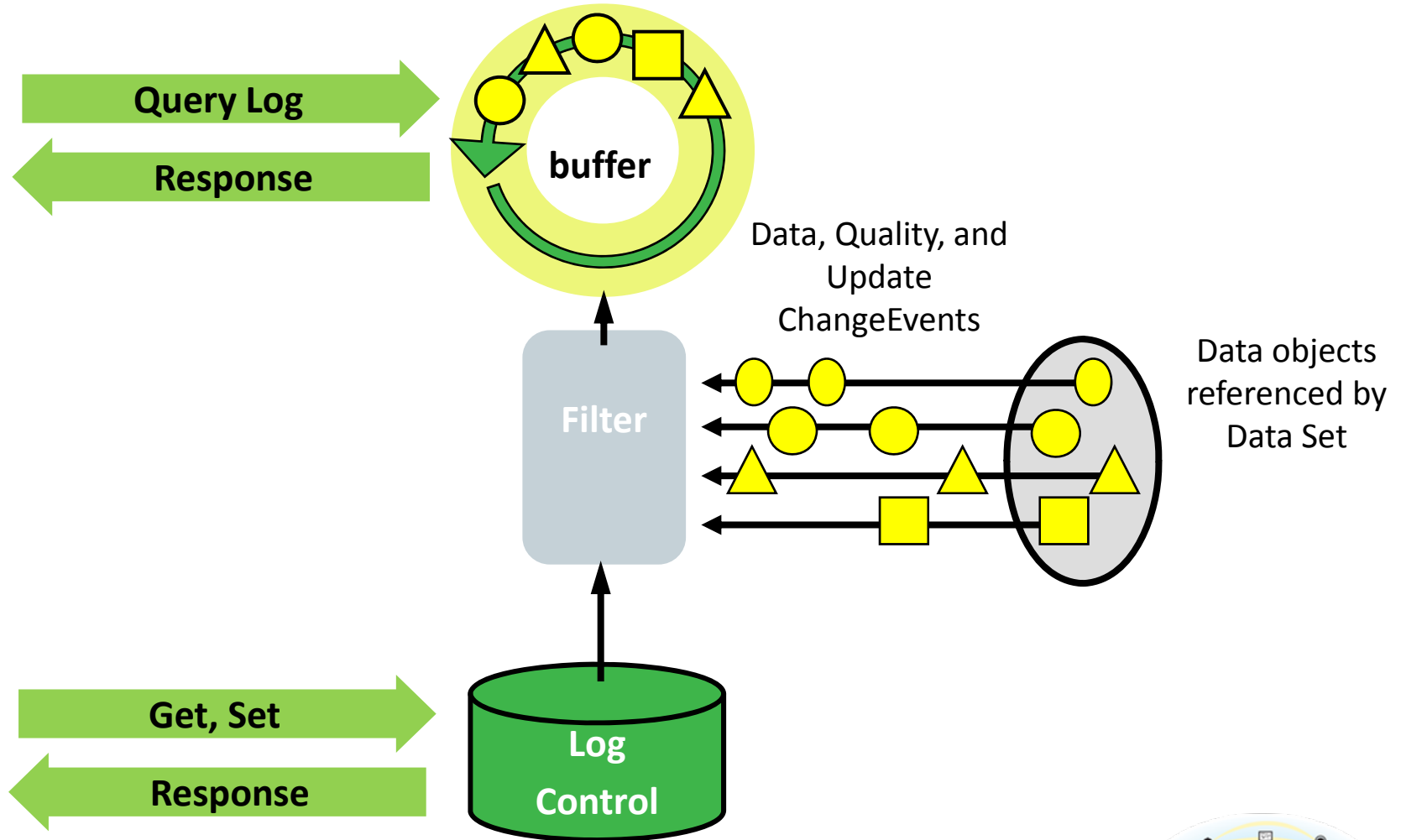


LOGGING MODEL

- Logs members of data sets
 - same triggering as Report Model
 - logged to circular buffer
 - can log multiple data sets
 - can be retrieved by multiple clients
- Retrieval by entry number or timestamp



LOGGING MODEL



GOOSE MODEL

- Generic Object Oriented System-wide Event (GOOSE)
 - fast and reliable distribution of data
 - send to multicast address
 - data set interrogation services
- Generic Substation Event (GSE)
 - sends fixed set of status outputs
 - also fast, reliable and multicast

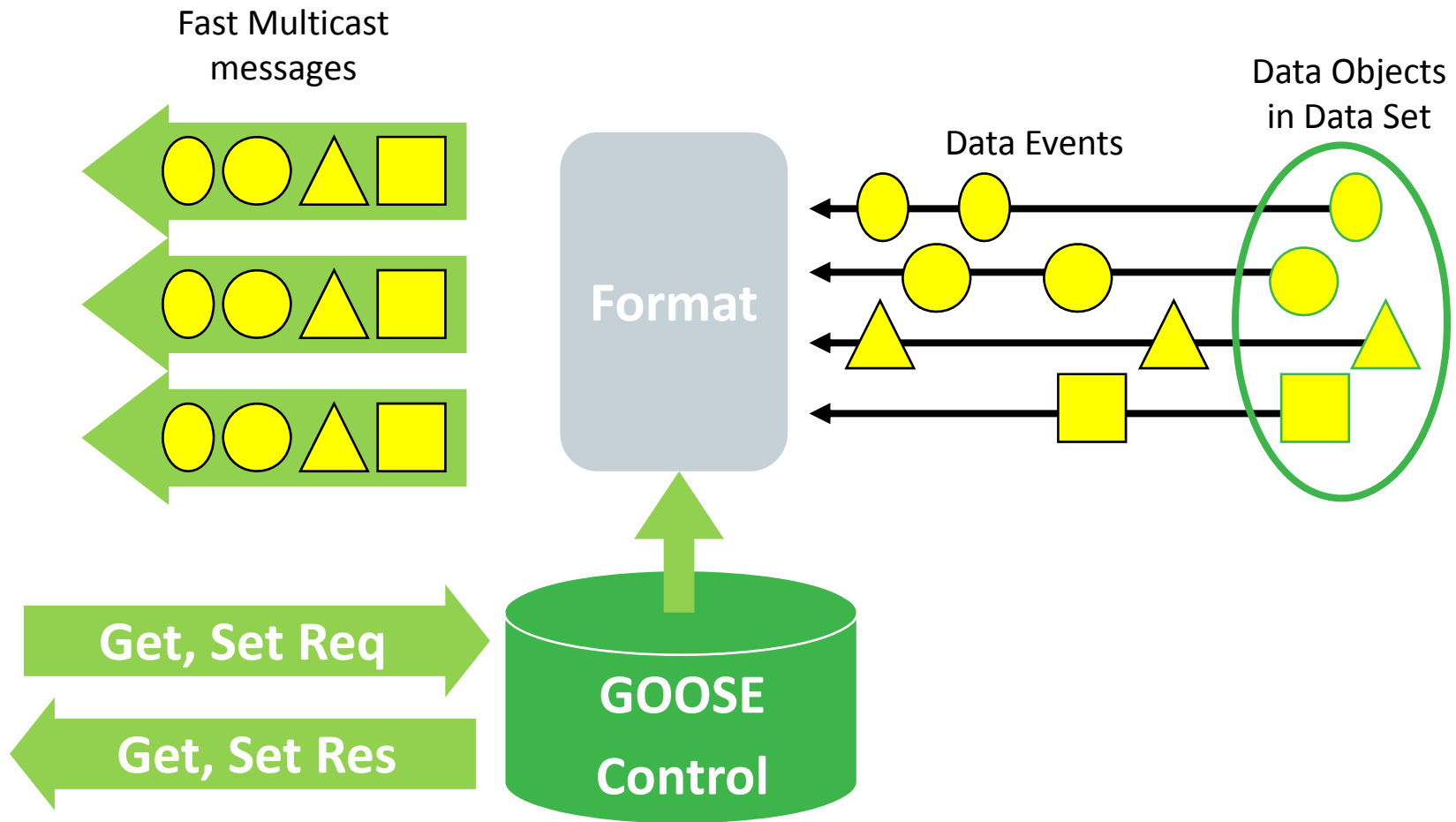


GOOSE MODEL

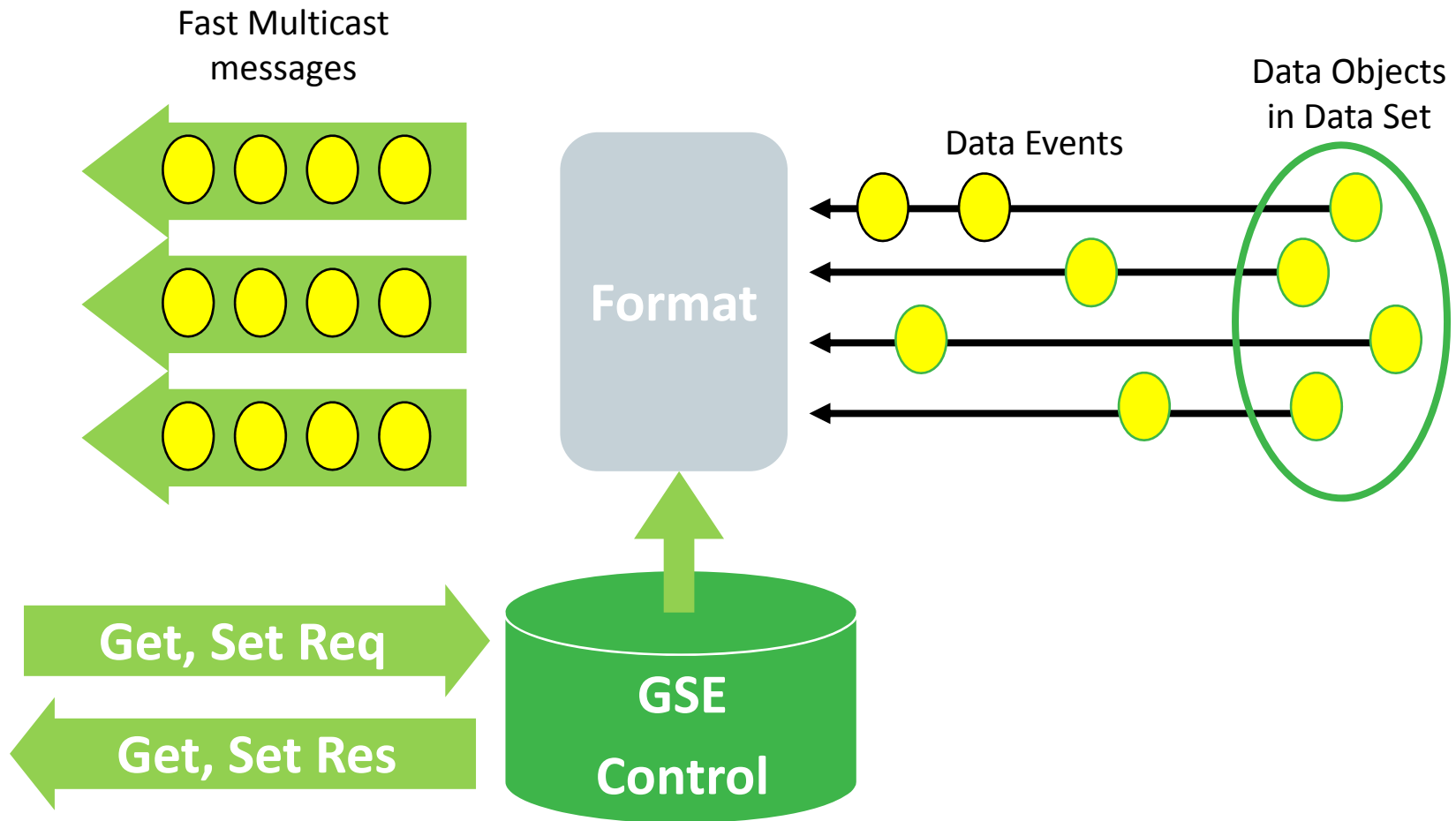
- Subscribers simply listen to multicast address
- Doesn't use TCP connections
- Multicast frames only on local LAN (no routing)



GOOSE MODEL



GSE MODEL



GOOSE AND GSE MODELS

- Link layer multicast with dedicated EtherTypes
- Messages are retransmitted
- Each message contains:
 - Sequence number
 - Snapshot of dataset
 - Time until next retransmission so timeouts and drops can be detected by subscriber



GOOSE AND GSE MODELS

- Control blocks contain:
 - Multicast address and VLAN identifier
 - Dataset selection
 - Enable/Disable

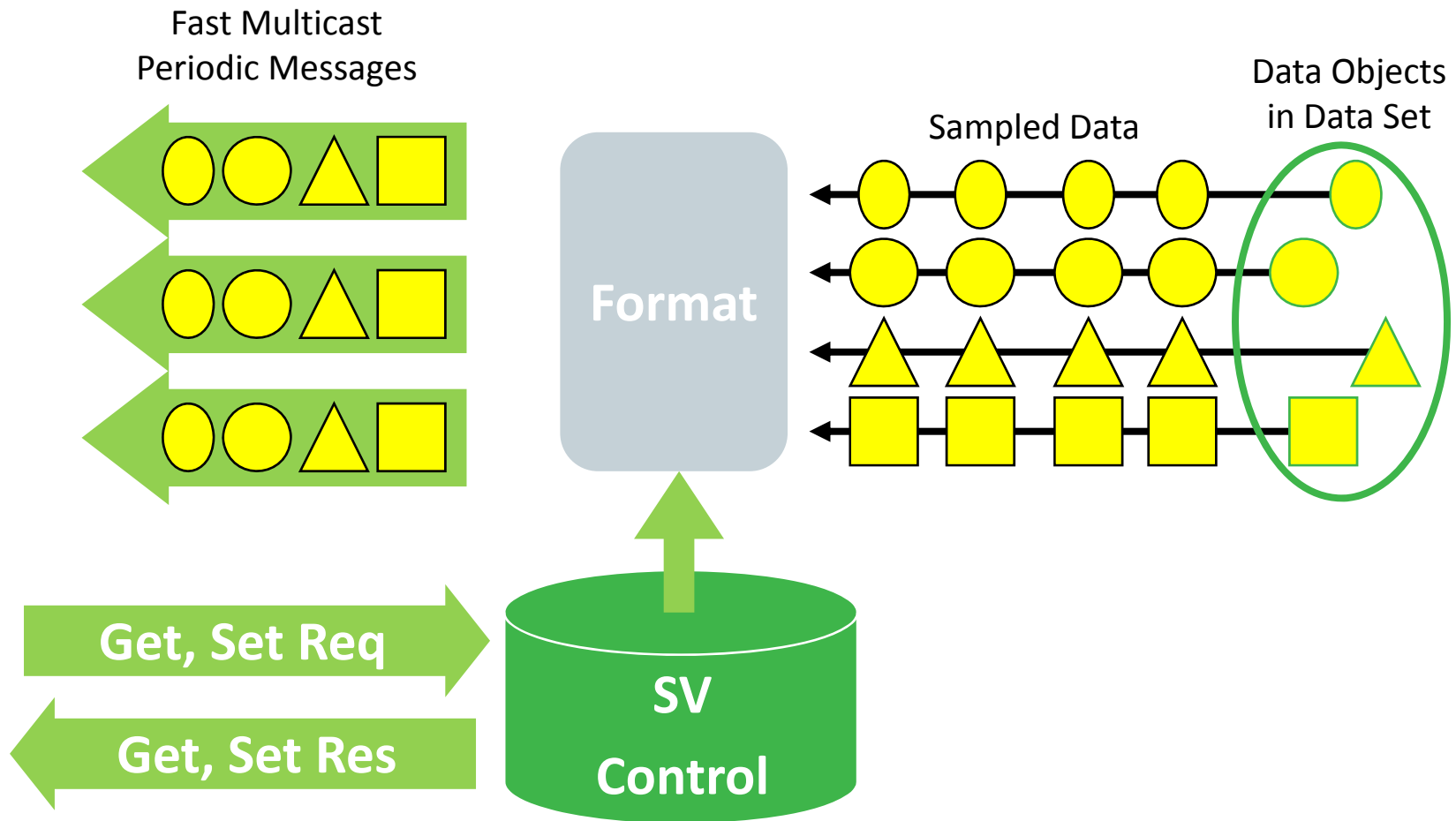


SAMPLED VALUES MODEL

- Used at Process level to supply synchronized samples
- Used at Bay/Unit level for Synchrocheck
- Samples multicast on local network segment
- Samples may be directed when enrolled across network segments



SAMPLED VALUES MODEL



SAMPLED VALUES MODEL

- Can be unicast or multicast
 - Link layer multicast with dedicated EtherTypes
 - TCP layer unicast (routable)
- Each message contains:
 - Snapshot of DataSet
 - Timestamp and sampling interval
- Control blocks contain
 - Dataset selection
 - Enable/Disable



OTHER SERVICES

- Association Services

- Basic connect/disconnect client-server model

- Discovery Services – self description

- GetServerDirectory – list of all Logical Devices
 - GetLogicalDeviceDirectory – all Logical Nodes
 - GetLogicalNodeDirectory – all Data Objects, DataSets, or files
 - GetDataDefinition – object structure and types
 - GetDataSetDirectory – members of DataSet



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OVERVIEW ON PARTS OF IEC 61850 (1)

Part 1 - Introduction and Overview

- Introduction and Overview of IEC 61850

Part 2 - Glossary

- Collection of terms and definitions

Part 3 - General Requirements

- Quality requirements (reliability, maintainability, system availability, security)
- Environmental conditions
- Auxiliary services
- Other standards and specifications



OVERVIEW ON PARTS OF IEC 61850 (2)

Part 4 - System and Project management

- Engineering (parameter classification, engineering tools, documentation)
- System lifecycle (product versions, discontinuation, support after discontinuation)
- Quality assurance (responsibilities, test equipment, type tests, system tests, FAT and SAT)



OVERVIEW ON PARTS OF IEC 61850 (3)

Part 5 - Communication Requirements for Functions and Device Models

- Logical interfaces
- Requirements and interoperability
- Substation automation system functions:
 - Function categories and list of functions
 - Specification of functions
 - Performance requirements of functions
- Logical node and PICOMs
 - Concept
 - Logical node categories and list of logical nodes
 - The use of logical nodes, interaction of logical nodes
 - Specification of message types with performance requirements
 - List of PICOMs and classification of PICOMs to message types
- Performance calculations for typical substation configurations



OVERVIEW ON PARTS OF IEC 61850 (4)

Part 6 - Substation automation system configuration language

- Overview on intended system engineering process
- The SCL object model
- Specification of the different file types used
- Specification of SCL
 - The SCL language
 - The SCL syntax elements
 - The XML schema for the SCL
- Example of a SCL file for a complete substation



OVERVIEW ON PARTS OF IEC 61850 (5)

Part 7 - Basic Communication Structure for Substation and Feeder Equipment

Part 7-1 - Principles and Models

- Introduction to Part 7-x
- Concepts of Communication Modeling in IEC 61850

Part 7-2 - Abstract Communication Service Interface

- Specification of abstract communication models and services
- Concepts of the hierarchical object model



OVERVIEW ON PARTS OF IEC 61850 (6)

Part 7-3 - Common data classes

Part 7-4 - Compatible logical node classes and data classes

- Collection of the logical nodes
- Specification of the logical nodes as collection of data classes

Part 8-1 - Mapping to MMS and ISO/IEC 8802-3

Part 9-1 – Sampled values over serial unidirectional multidrop point to point link

Part 9-2 – Sampled values over ISO/IEC 8802-3



OVERVIEW ON PARTS OF IEC 61850 (6)

Part 10 - Conformance Testing

- Conformance test procedures
- Quality assurance and testing
- Required documentation
- Device related conformance testing
- Certification of test facilities, requirement and validation of test equipment



WHO SHOULD KNOW WHAT FROM IEC61850?

	Part 1	Part 5	Part 7-1	Part 7-2	Part 7-3	Part 7-4	Part 6	Part 8-1, 9-x
	Introduction	Requirements	Principles	ACSI	CDC	LN	SCL	mapping to MMS
UTILITY								
Manager								
Engineer								
VENDOR								
Application E.								
Communication E.								
Product Manager								
Marketing								
CONSULTANT								
Application E.								
Communication E.								
others								

important

partly important

minor importance



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FUTURE DIRECTIONS FOR IEC 61850

- Extensions and technical reports
- Edition 2 preparation
- Edition 3 planning



DOCUMENT NAMING AND NUMBERING

- Domain specific extensions
 - x00 – Substation automation
 - x10 – Hydro power plants
 - x20 – Distributed energy resources
 - Example: IEC 61850-7-410 – Logical nodes for hydro power plants
- New part 61850-7-5xx
 - IEC 61850-7-500 – Use of logical nodes for substation automation



DOCUMENT NAMING AND NUMBERING

- New part IEC 61850-90-x – Reports “How to...”
 - IEC 61850-90-1: Using IEC 61850 for communication between substations
 - IEC 61850-90-2: Using IEC 61850 for communication between substations and control center
 - IEC 61850-90-3: Using IEC 61850 for condition monitoring
 - IEC 61850-90-4: Network engineering guidelines



HYDRO EXTENSIONS

- IEC 61850-7-410: Hydroelectric power plants – Communication for monitoring and control
 - Object models for Hydro Power Plants
 - Electrical, mechanical and hydrological functions and sensors



DER EXTENSIONS

- IEC 61850-7-420: Communications Systems for Distributed Energy Resources (DER)
 - Object models for distributed energy resources
 - Reciprocating engines, fuel cells, microturbines, wind turbines, photovoltaic and storage devices



IEC 870-5 101/104 GUIDELINES

- IEC 61850-80-1: Guideline to exchange information from a CDC based data model using IEC 60870-5-101 / -104
 - Technical Specification
 - Mapping of IEC 61850 CDC on IEC 60870-5-104/101 ASDUs



DOCUMENTS IN PREPARATION

- IEC 61850-90-1: Use of IEC 61850 for communication between substations
- IEC 61850-90-2: Use of IEC 61850 for communication between substations and control centers



DOCUMENTS IN PREPARATION

- Technical reports describing
 - The use cases considered
 - The impact on the communication
 - The impact on the modeling
 - The impact on the engineering
- Results will be used to update the standards (Amendment / new Edition)



IEC 61850-90-1 USE CASES

•Protection functions

- Differential protection
- Distance protection with permissive and blocking schemes
- Directional and phase comparison protection
- Transfer tripping

•Control function

- Autoreclosing
- Interlocking
- Generator and load shedding



IEC 61850-90-2 USE CASES

- SCADA
- Disturbance recording
- Metering
- Wide area monitoring
- Power quality monitoring
- Asset supervision
- Management of remote parameter and configuration changes



NEW DOCUMENTS PLANNED

- Series of documents describing the use of the logical nodes to model the application functions
 - IEC 61850-7-500 – Use of logical nodes to model the functions of a substation automation system
 - IEC 61850-7-510 – Use of logical nodes to model the functions of a hydro power plant
- Work on these parts has just started



IEC 61850 EDITION 2

•Modeling Extensions

- Statistical and historical data
 - Min, max over some period
 - Calculated values stored (e.g. max/hour over 24 hours)
- Power quality
 - RMS voltage variation per IEC 61000-4-30 , IEEE 1159
 - Transients (IEEE 1159)
 - Unbalance variation
 - Frequency variation
- New LNs from IEC 61850-7-410



IEC 61850 EDITION 2

- Documentation of inputs to LNs
 - InRef specifies link to another object/attribute
- Functional hierarchies
 - Provides mechanism 'nesting' logical devices with respect to Mod, Loc, Health, etc.
- Information about local time
 - Offset to UTC in nameplate
 - Daylight Savings Time switch in LLN0



IEC 61850 EDITION 2

•Substation Configuration Language Extensions

- New .iid file type for to convey project-specific changes to an IED instance from IED configuration tool to system configuration
- New .sed file type to exchange interfacing information between two projects (systems) needing to exchange data
- SCL conformance statements for vendors of SCL tools



IEC 61850 EDITION 2

- Changes to abstract services: 61850-7-2
 - Improvements/clarifications to reporting
 - GSSE moved to Annex (Goose preferred)
 - Improvements to readability, formal models



PLANS FOR EDITION 3

- Basic model extensions

- SCL description of programmable logic
- Network and system management
- Redundancy
- Security aspects from IEC 62351
- Security – Role based access
- Time synchronisation using IEEE 1588
- Download, activation of configuration files



PLANS FOR EDITION 3

- Domain model extensions
 - Common usable elements from DER standard
 - Low voltage applications
 - Eliminate IED specific settings
- Testing
 - Testing scenarios
 - System testing?

